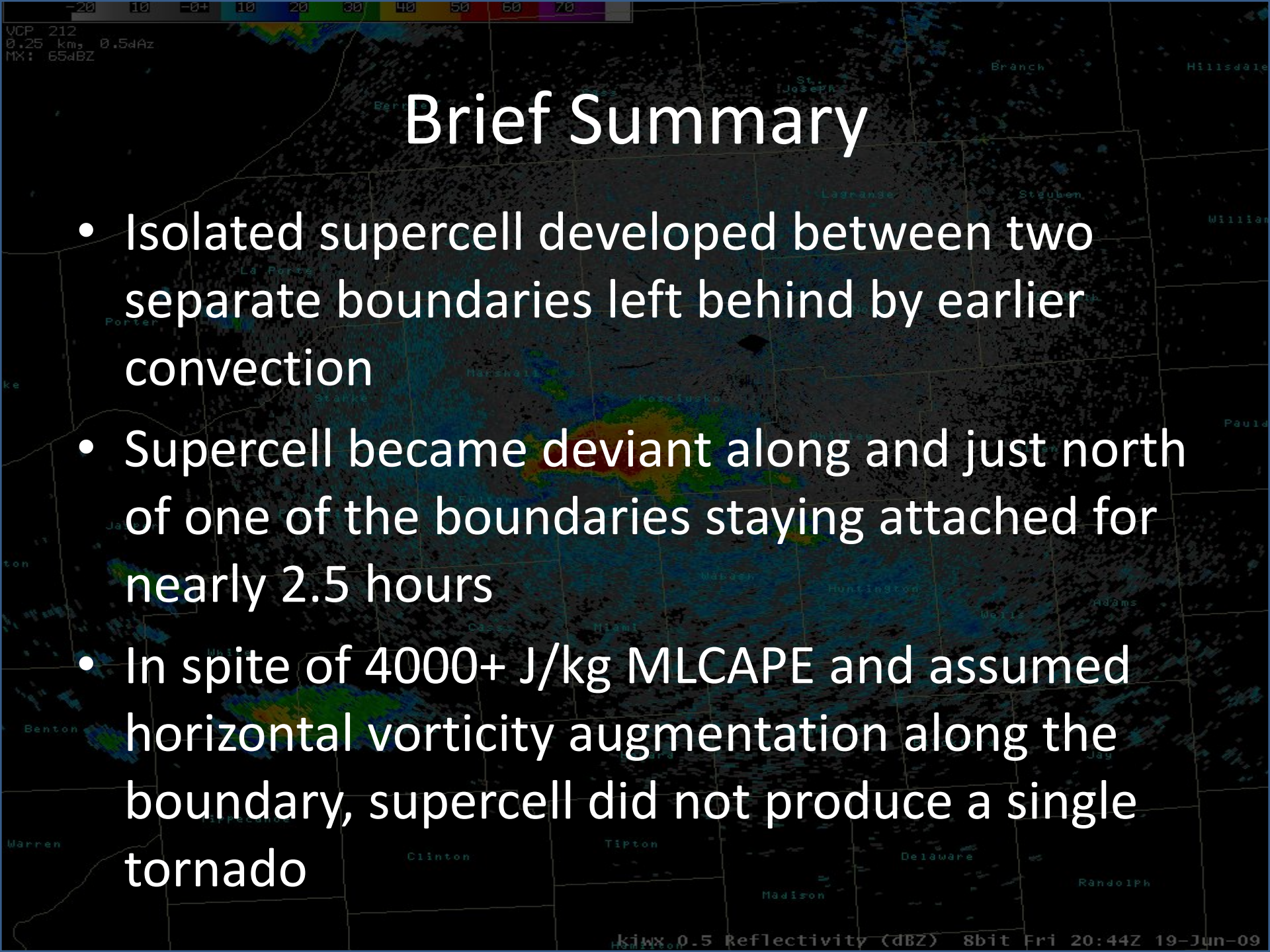


A Review of a Rare Classic Supercell in Northern Indiana and Possible Explanations for Tornadogenesis Failure

B.J. Simpson

NWS Northern Indiana



Brief Summary

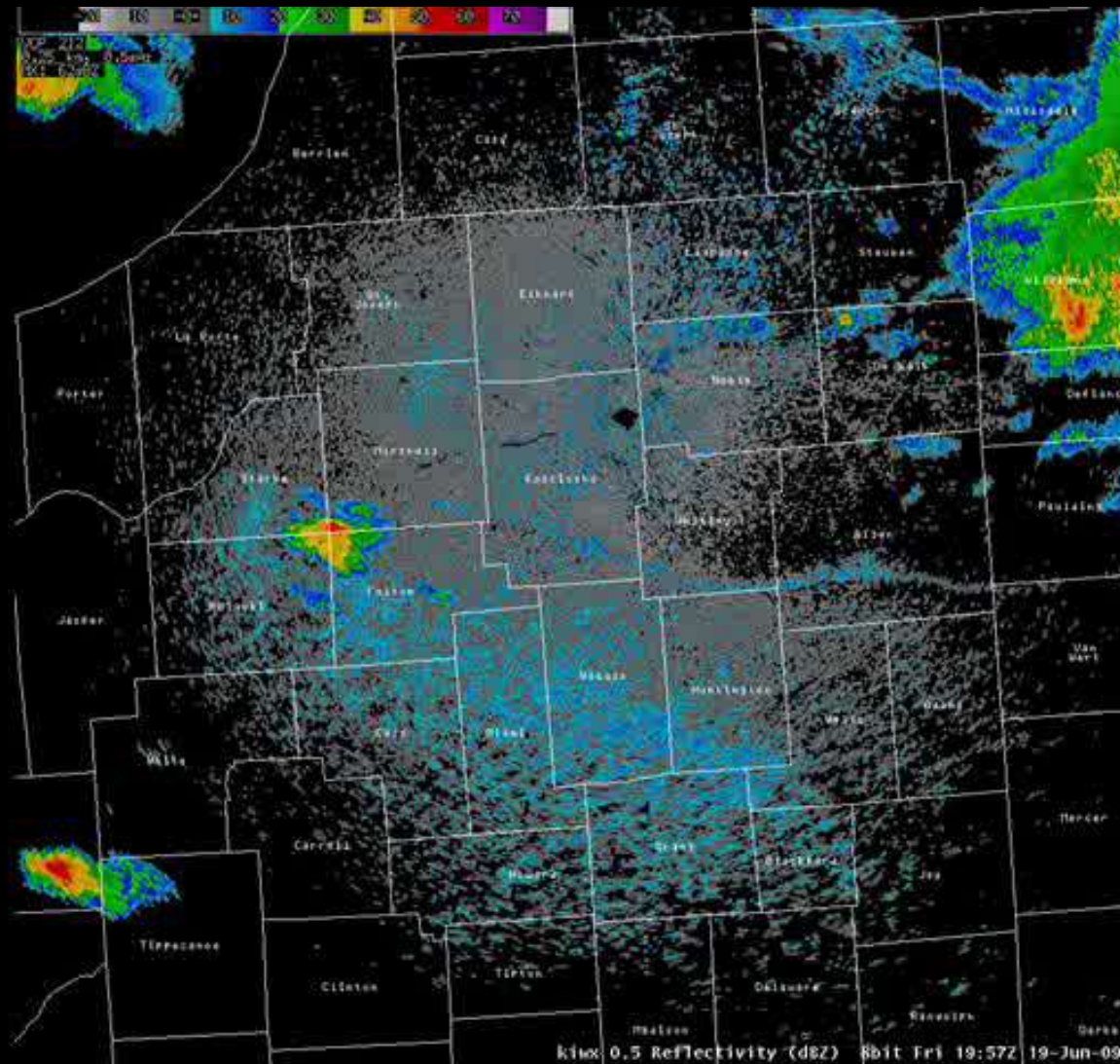
- Isolated supercell developed between two separate boundaries left behind by earlier convection
- Supercell became deviant along and just north of one of the boundaries staying attached for nearly 2.5 hours
- In spite of 4000+ J/kg MLCAPE and assumed horizontal vorticity augmentation along the boundary, supercell did not produce a single tornado



Reasons for Study

- Very few “classic” supercells develop or move into the KIWX CWA
- Most tornadoes in the KIWX CWA form in QLCS or low topped convection
- So why wouldn’t a rare textbook supercell riding just north of a well defined boundary produce a tornado?

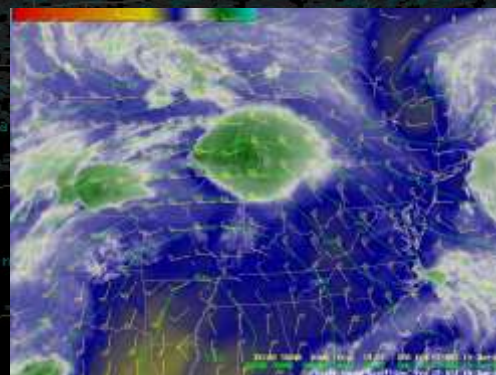
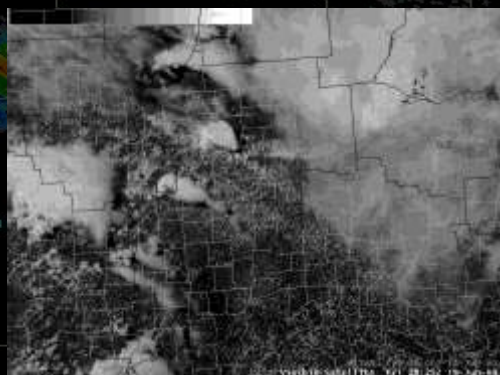
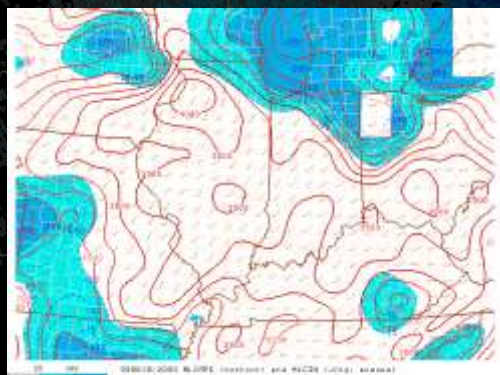
Storm Lifecycle Loop



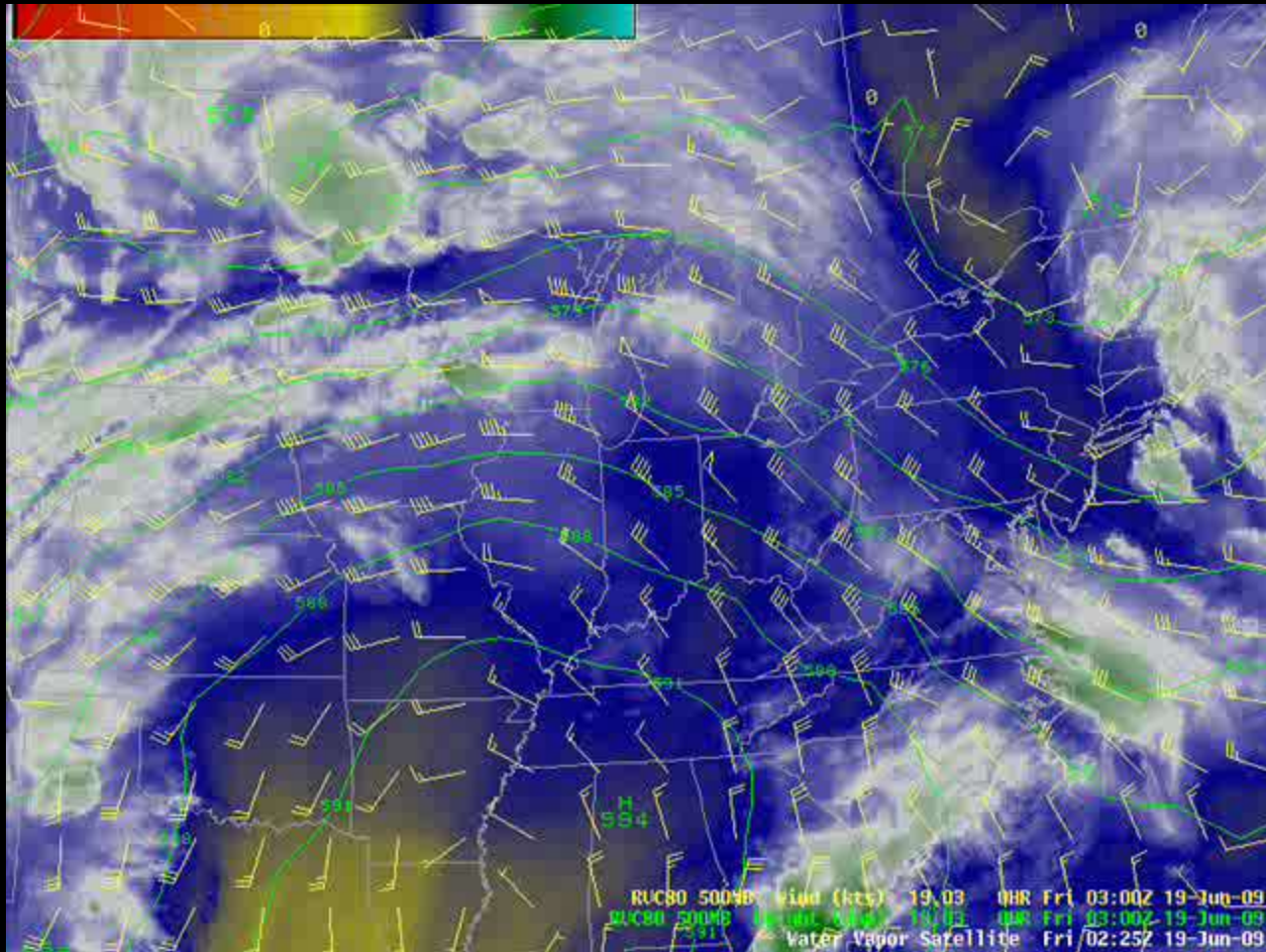
VCP 212
0.25 km, 0.5dBZ
MX: 65dBZ

Pre-Storm Environment

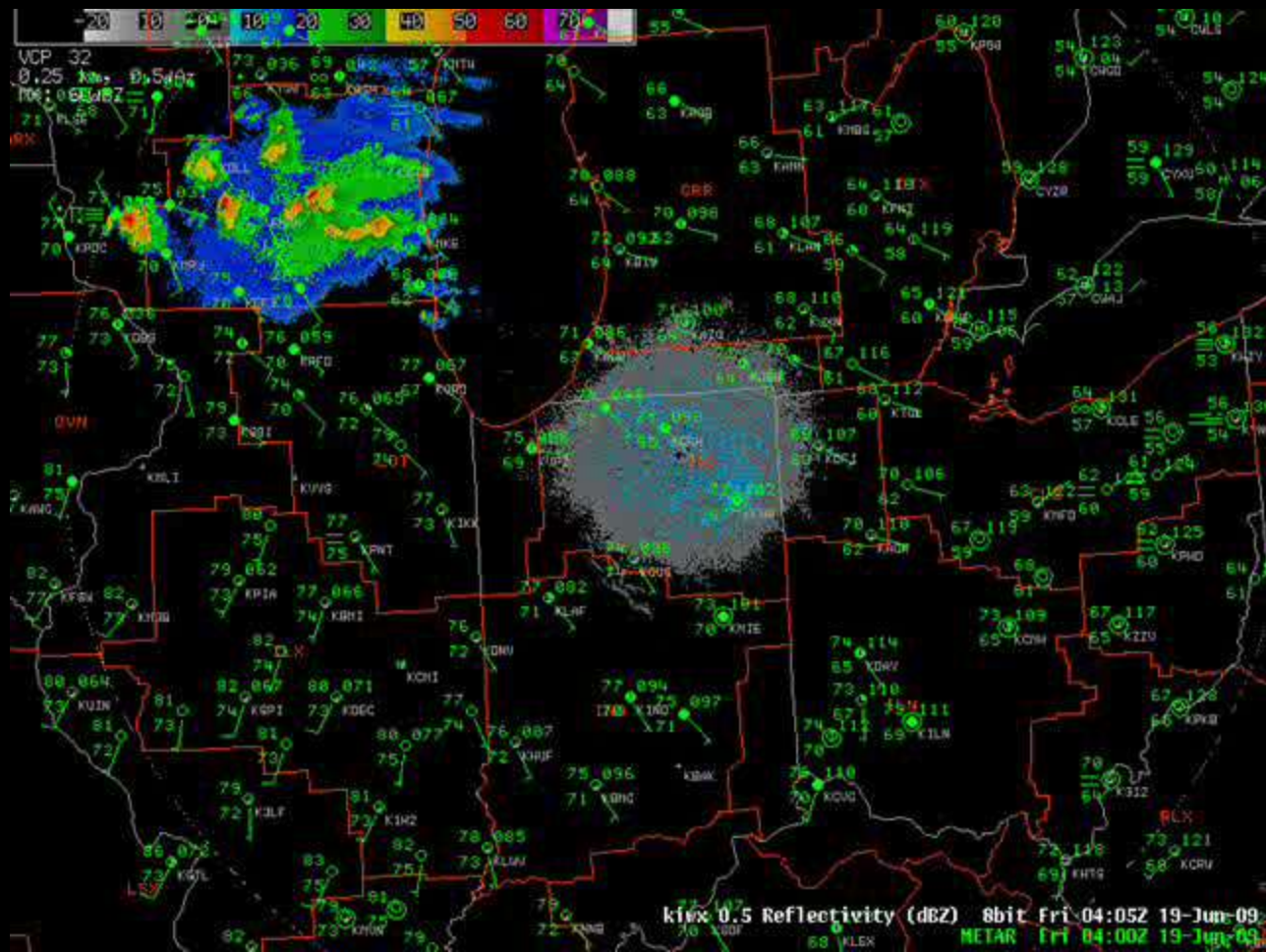
- Several important synoptic and mesoscale factors came together that led to supercell development the afternoon of June 19th.



Water Vapor/500mb Heights/Winds



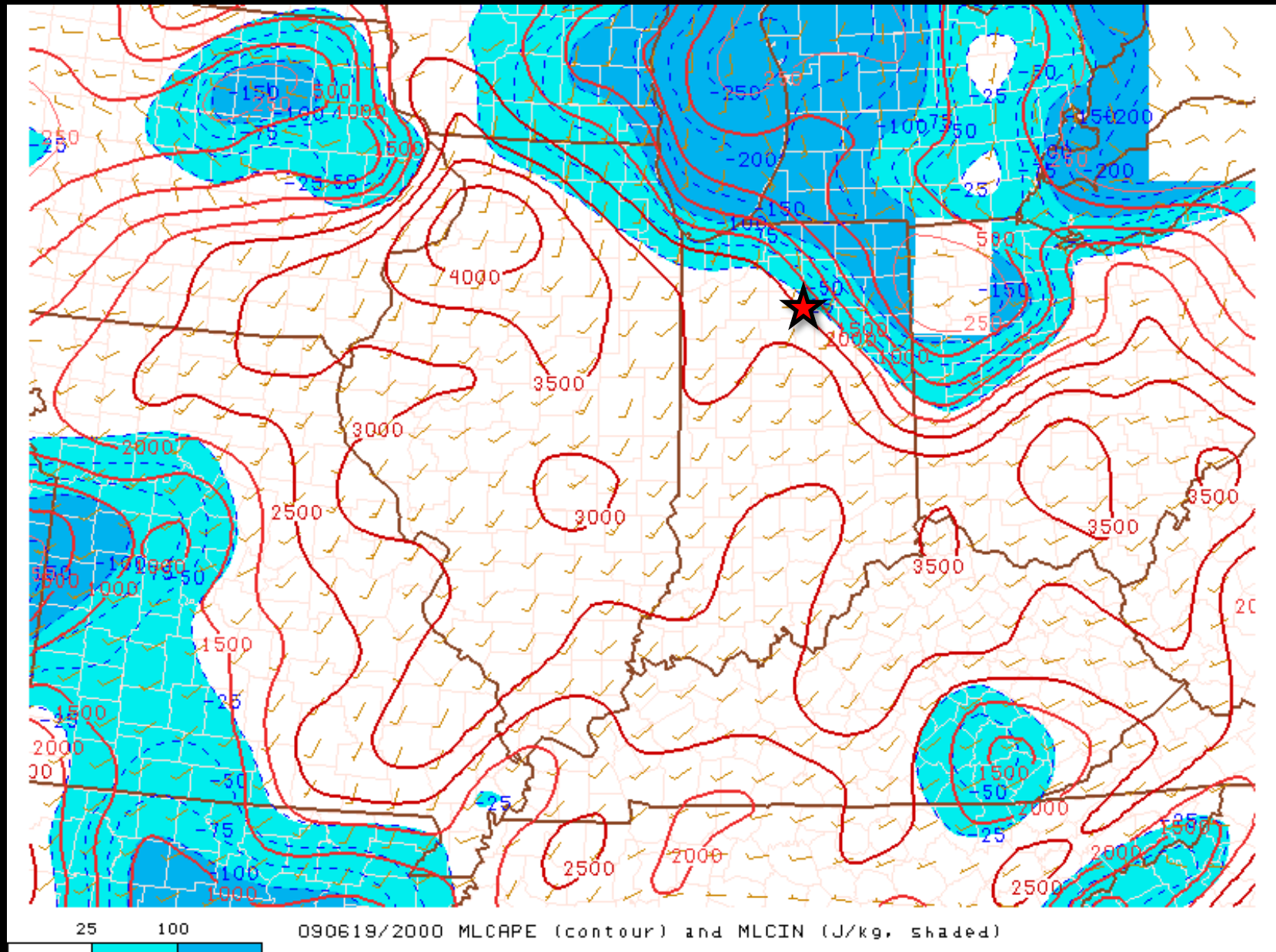
June 19 Radar Mosaic



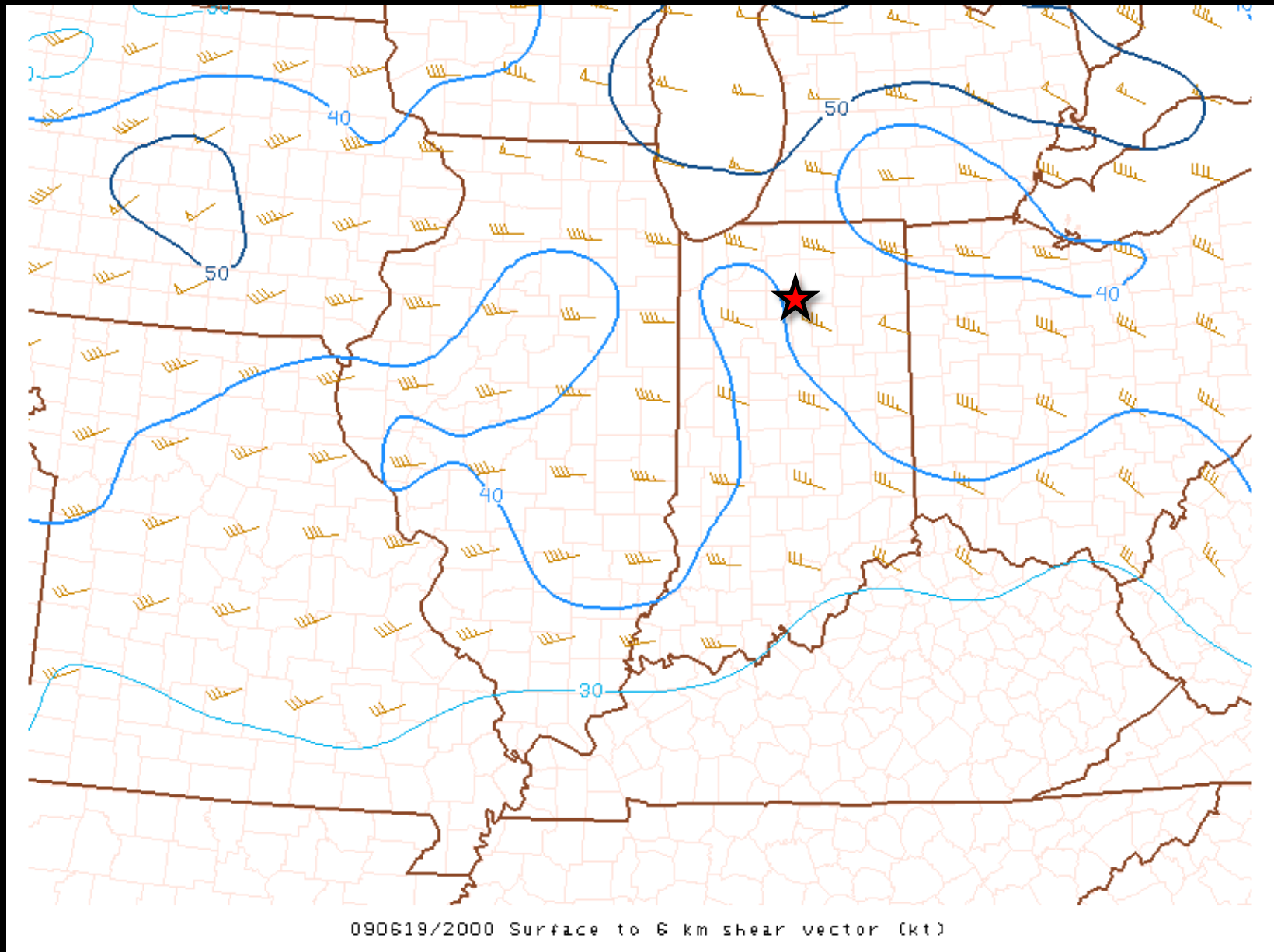
Visible Satellite



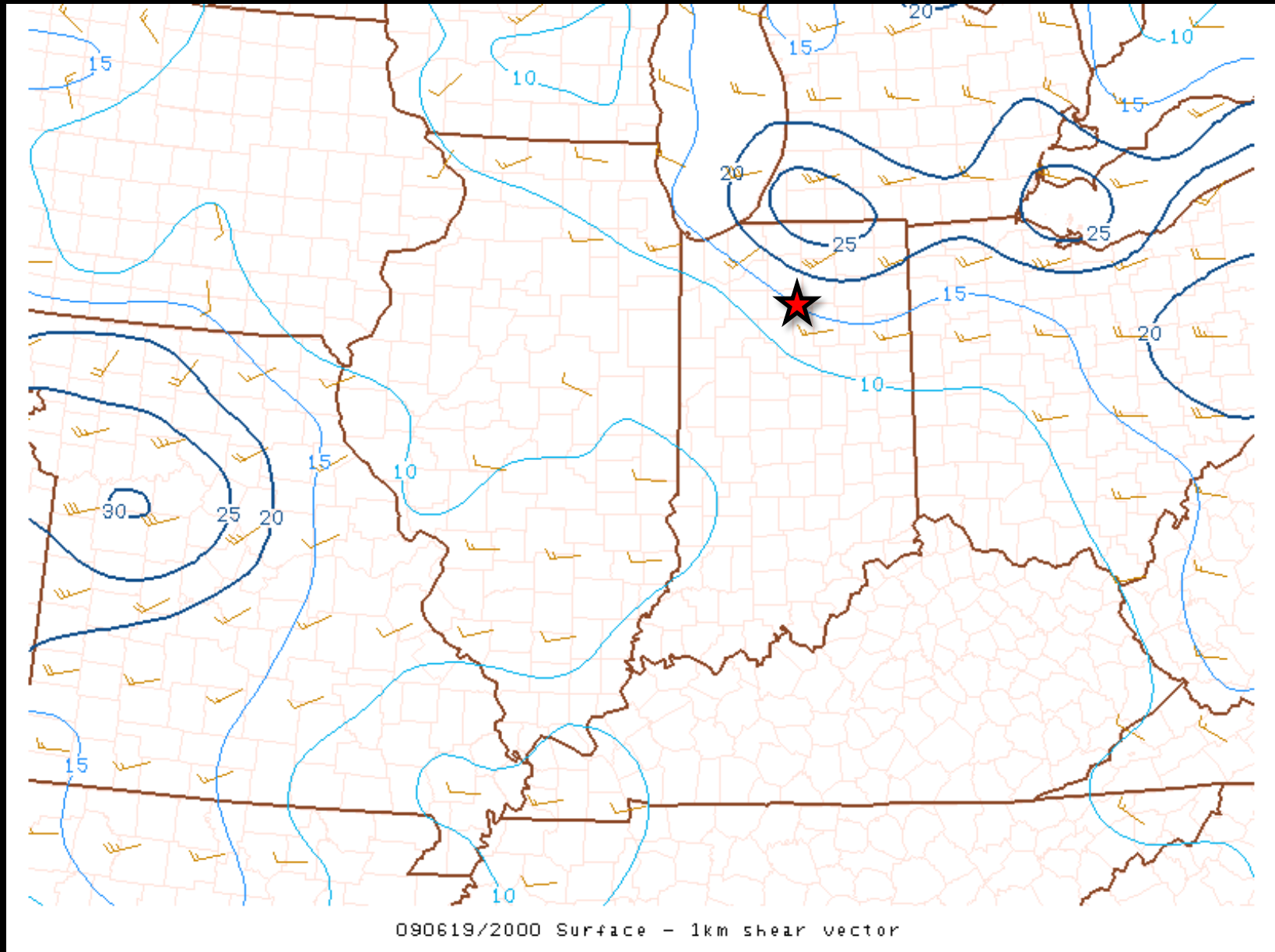
20 UTC MLCAPE – RUC Mesoanalysis



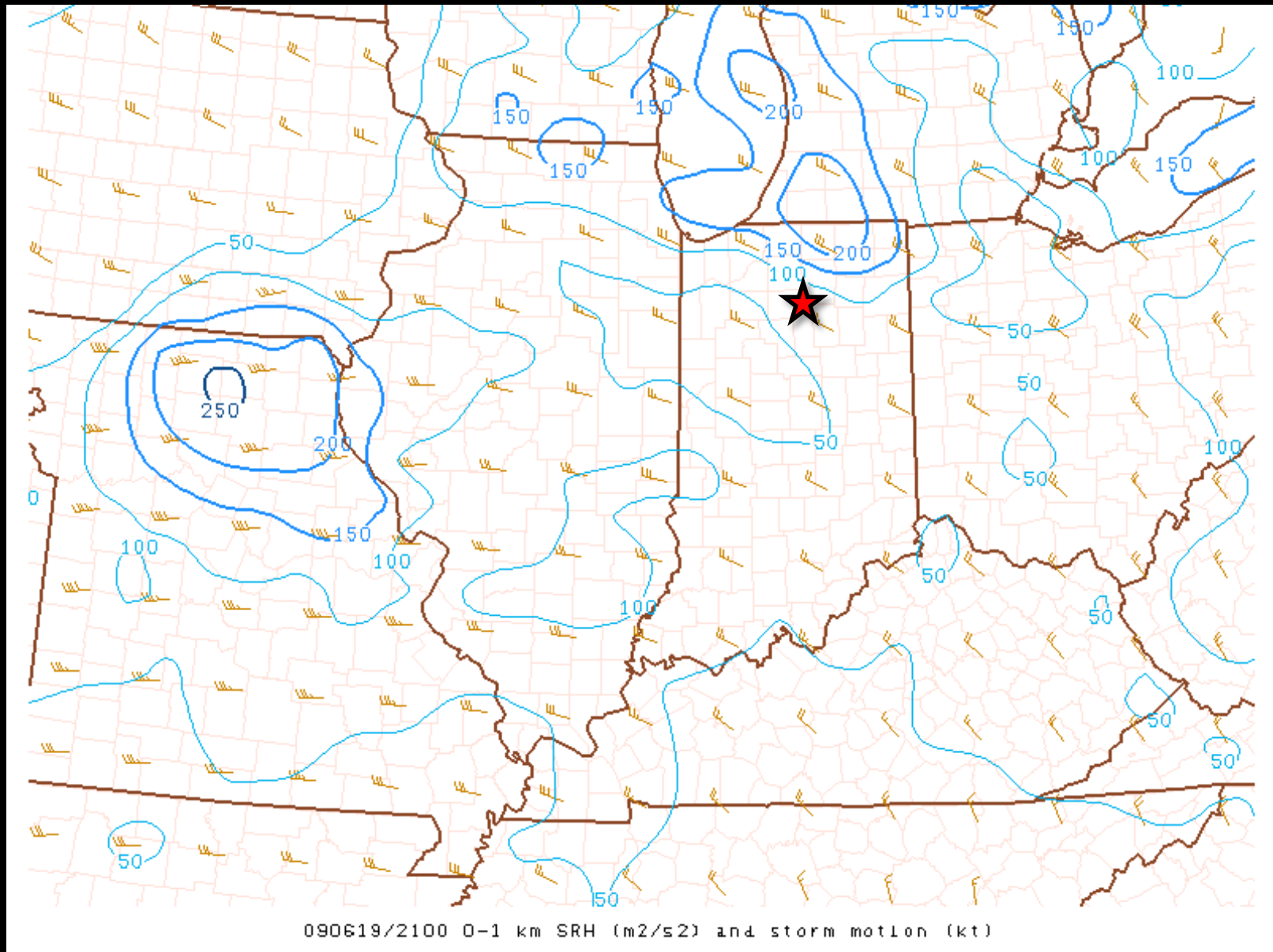
20 UTC 0-6 km Shear – RUC Mesoanalysis



20 UTC 0-1 km Shear – RUC Mesoanalysis

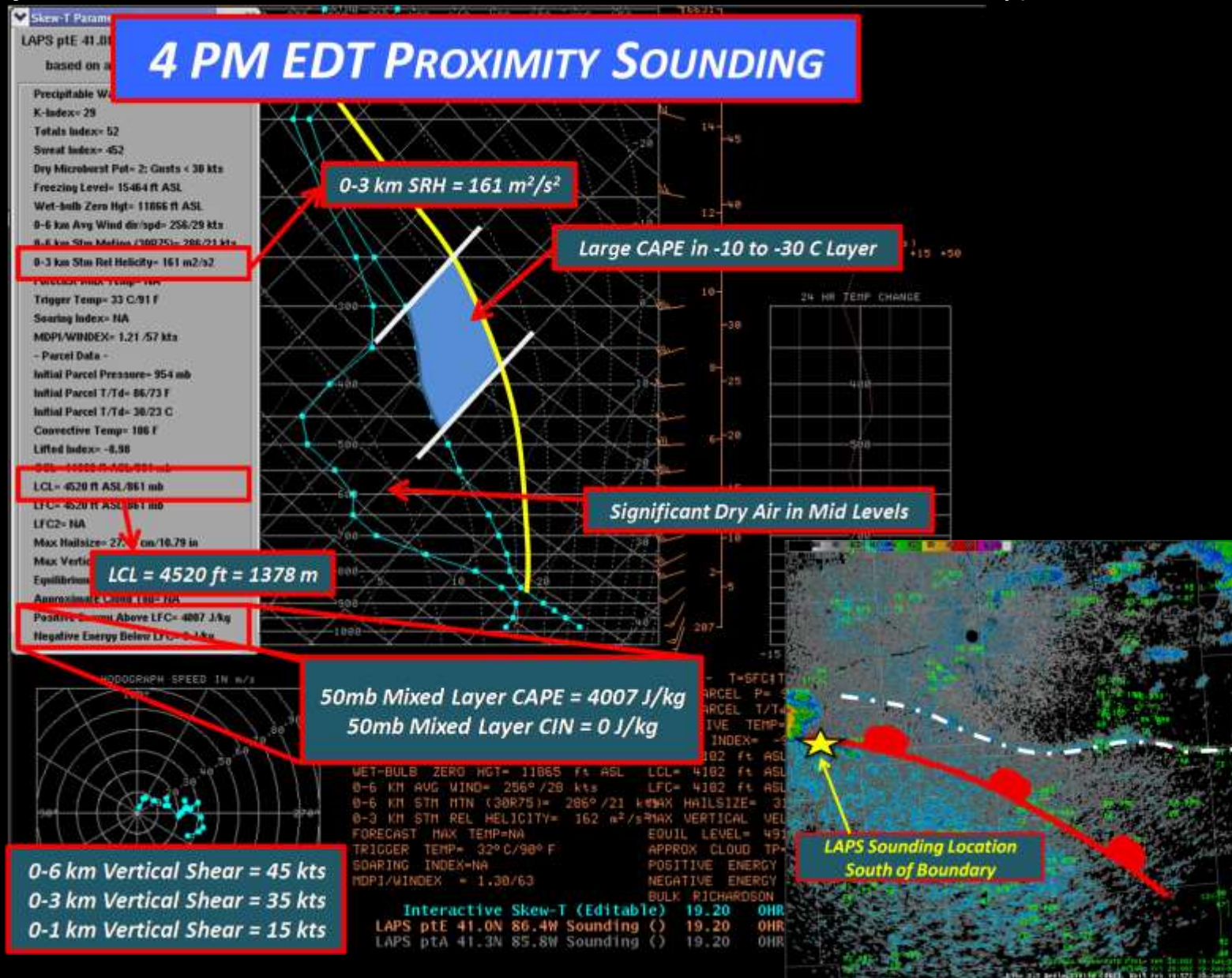


21 UTC 0-1 km SRH – RUC Mesoanalysis

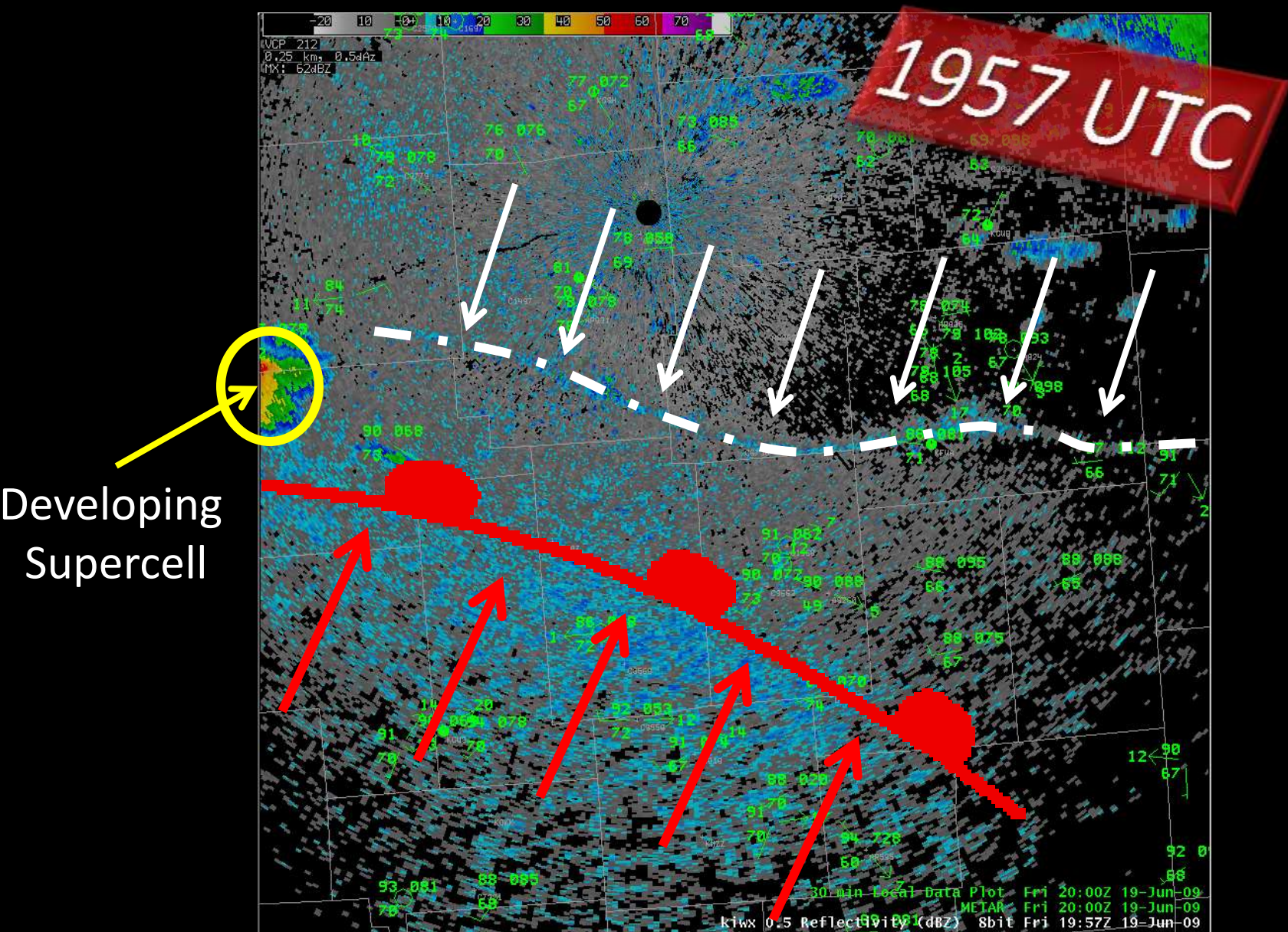


LAPS Proximity Sounding

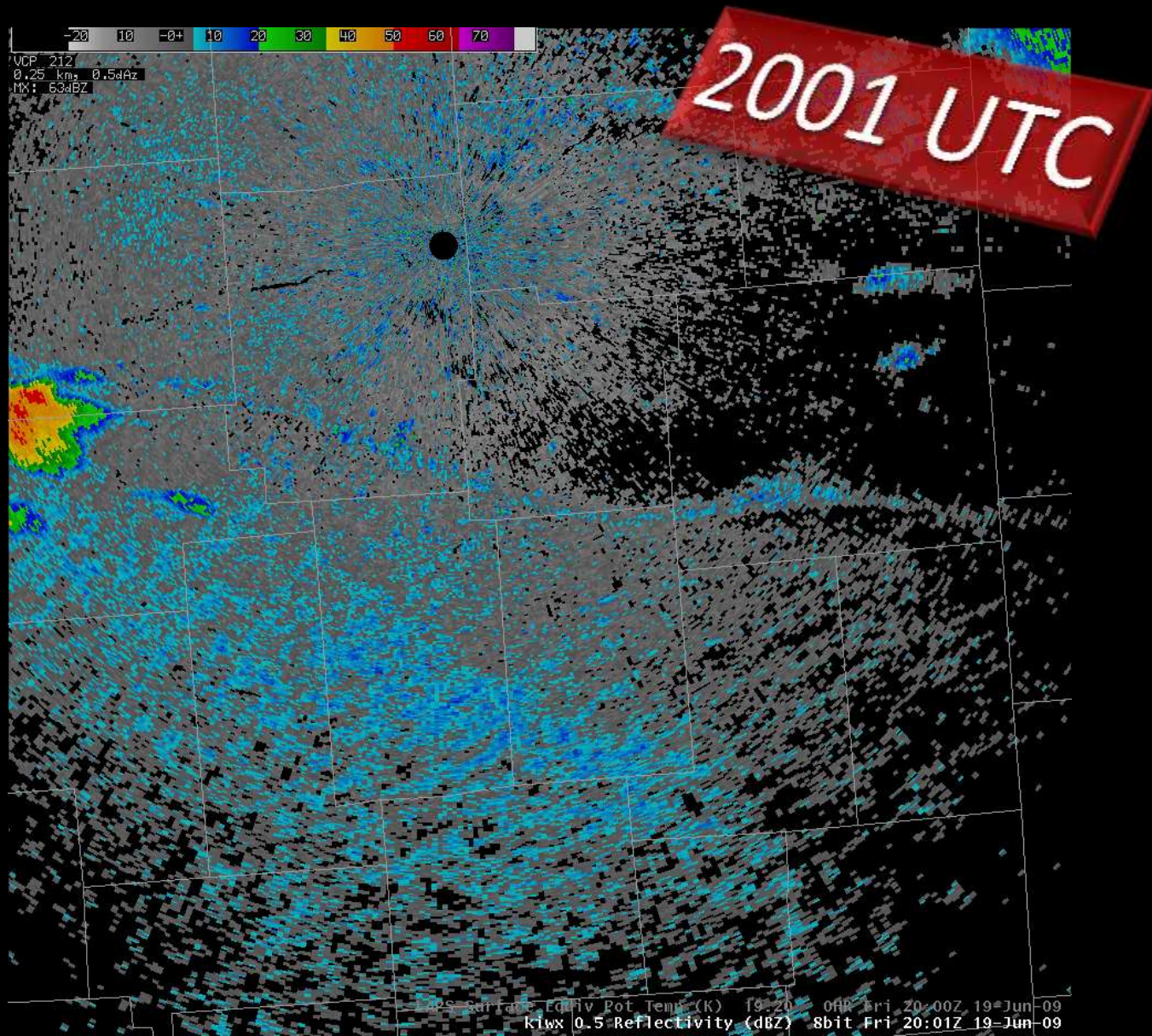
(Adjusted to Reflect Surface Conditions South of the Boundary)



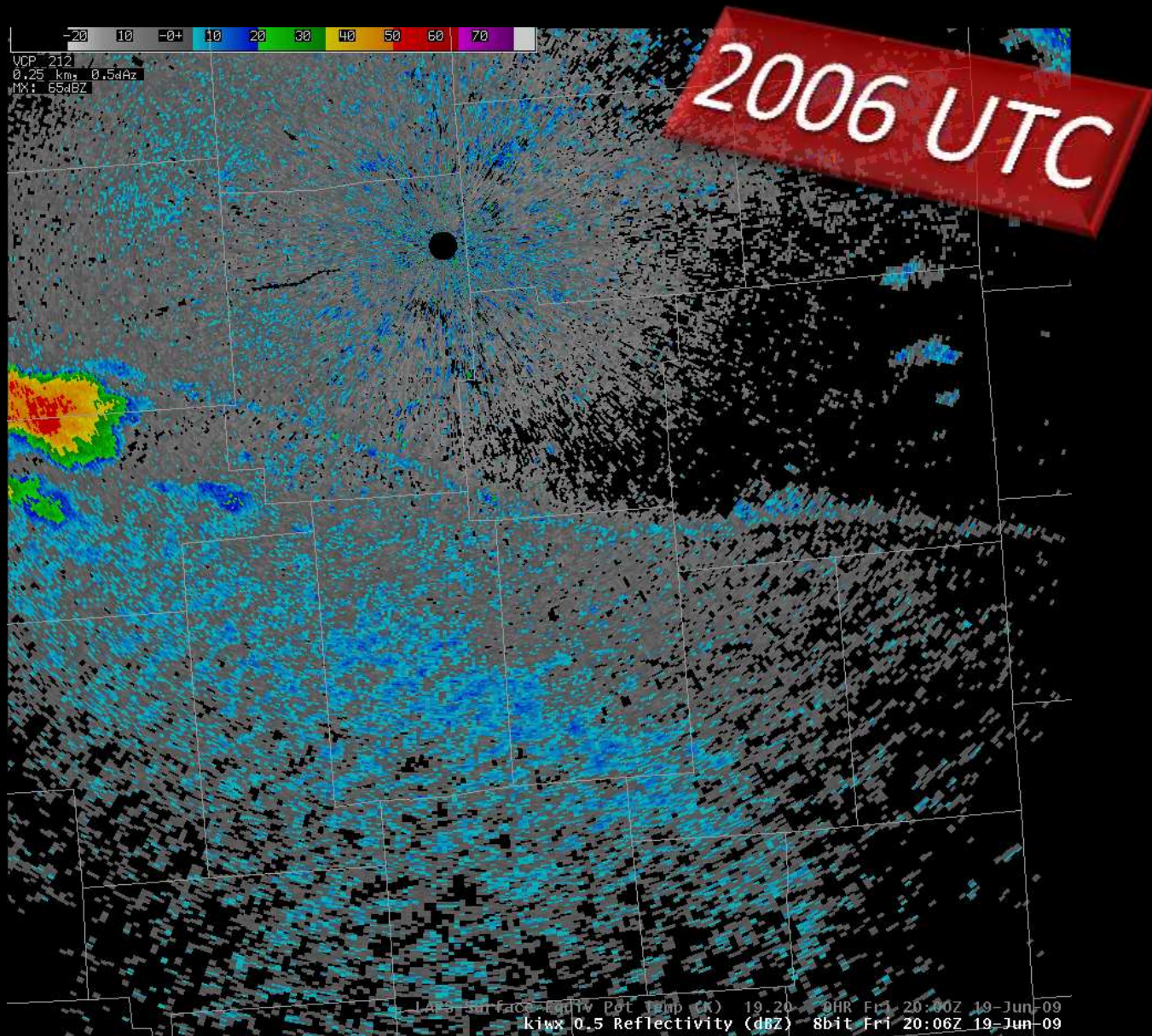
0.5 Degree Reflectivity



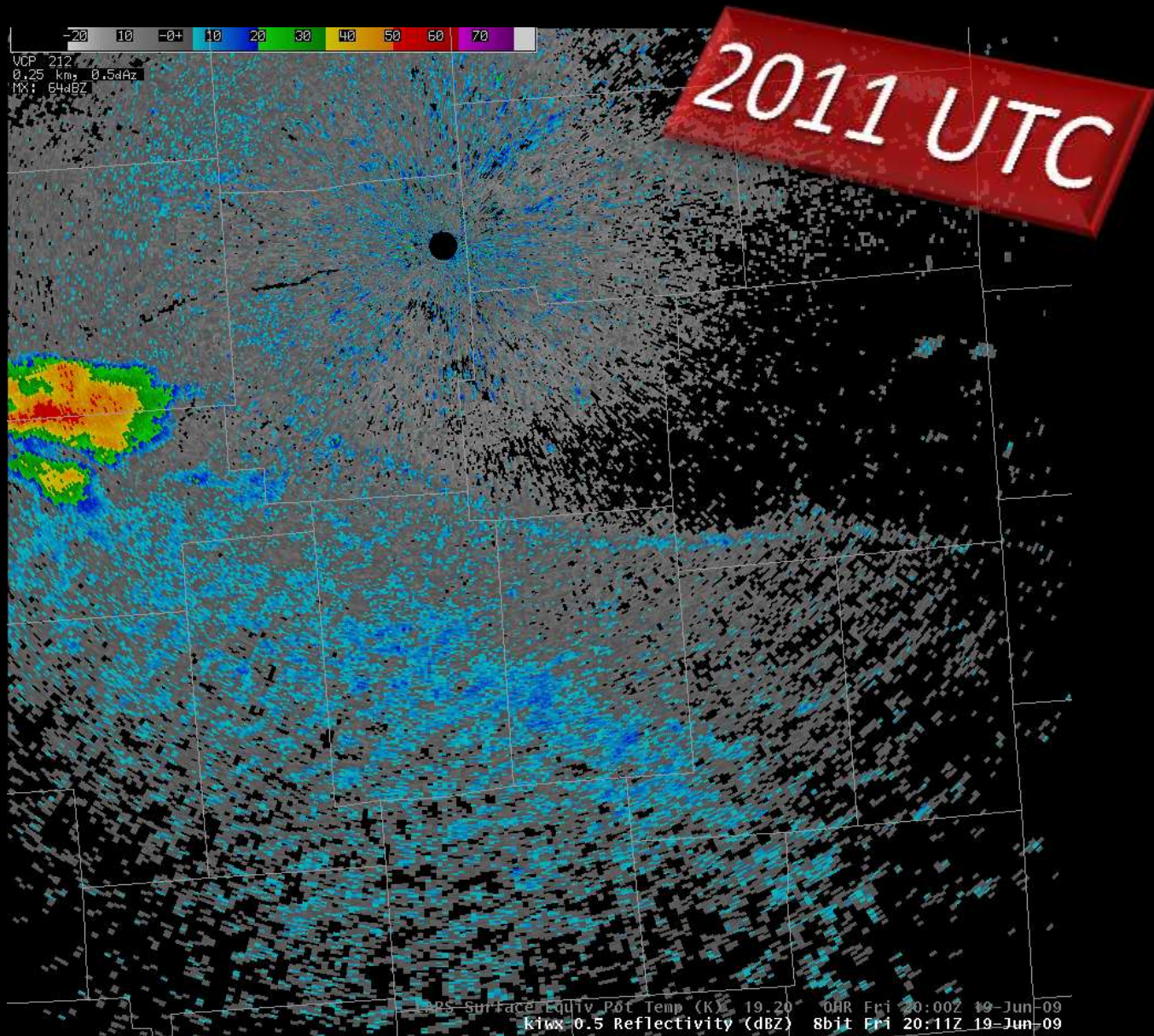
0.5 Degree Reflectivity



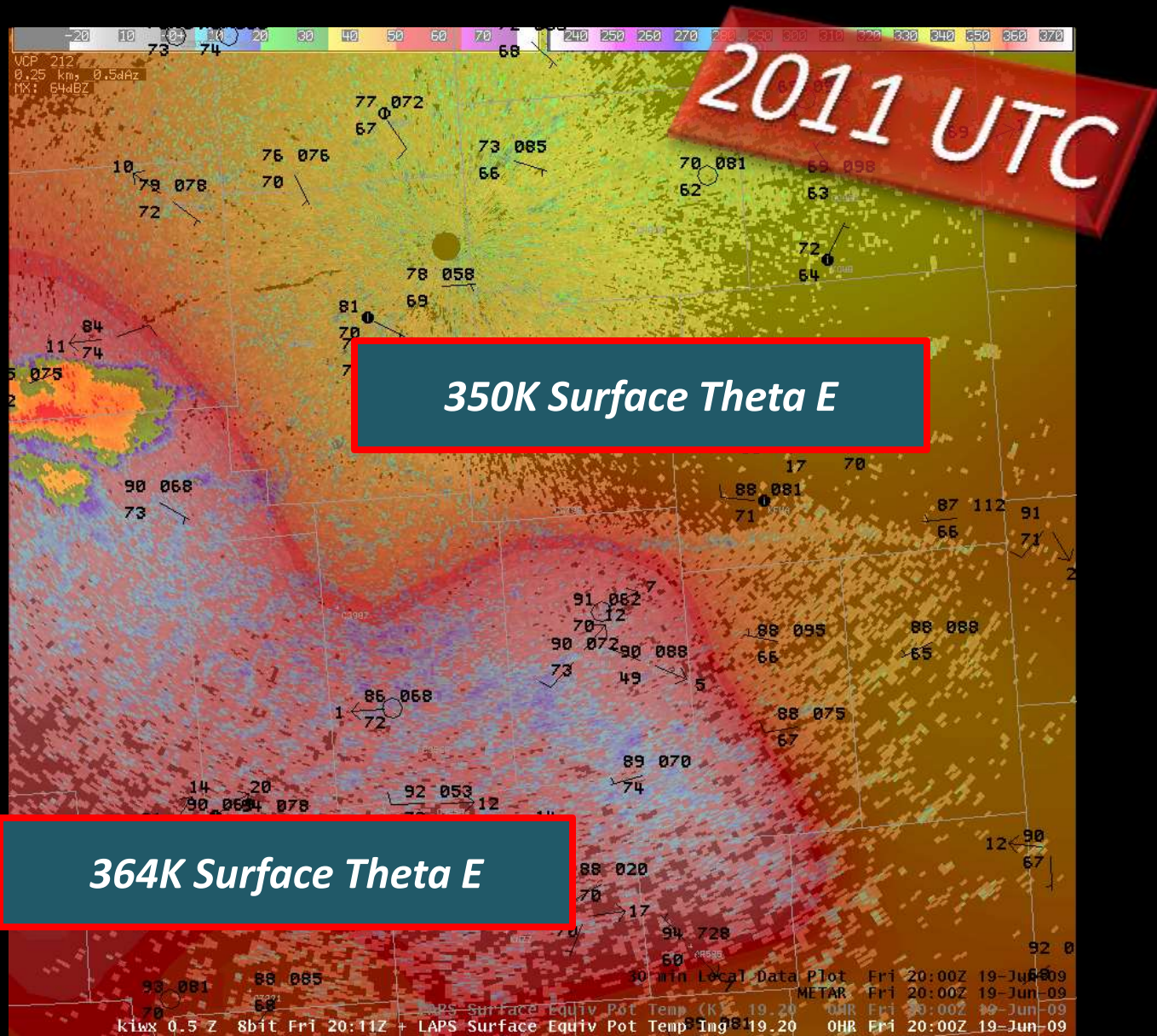
0.5 Degree Reflectivity



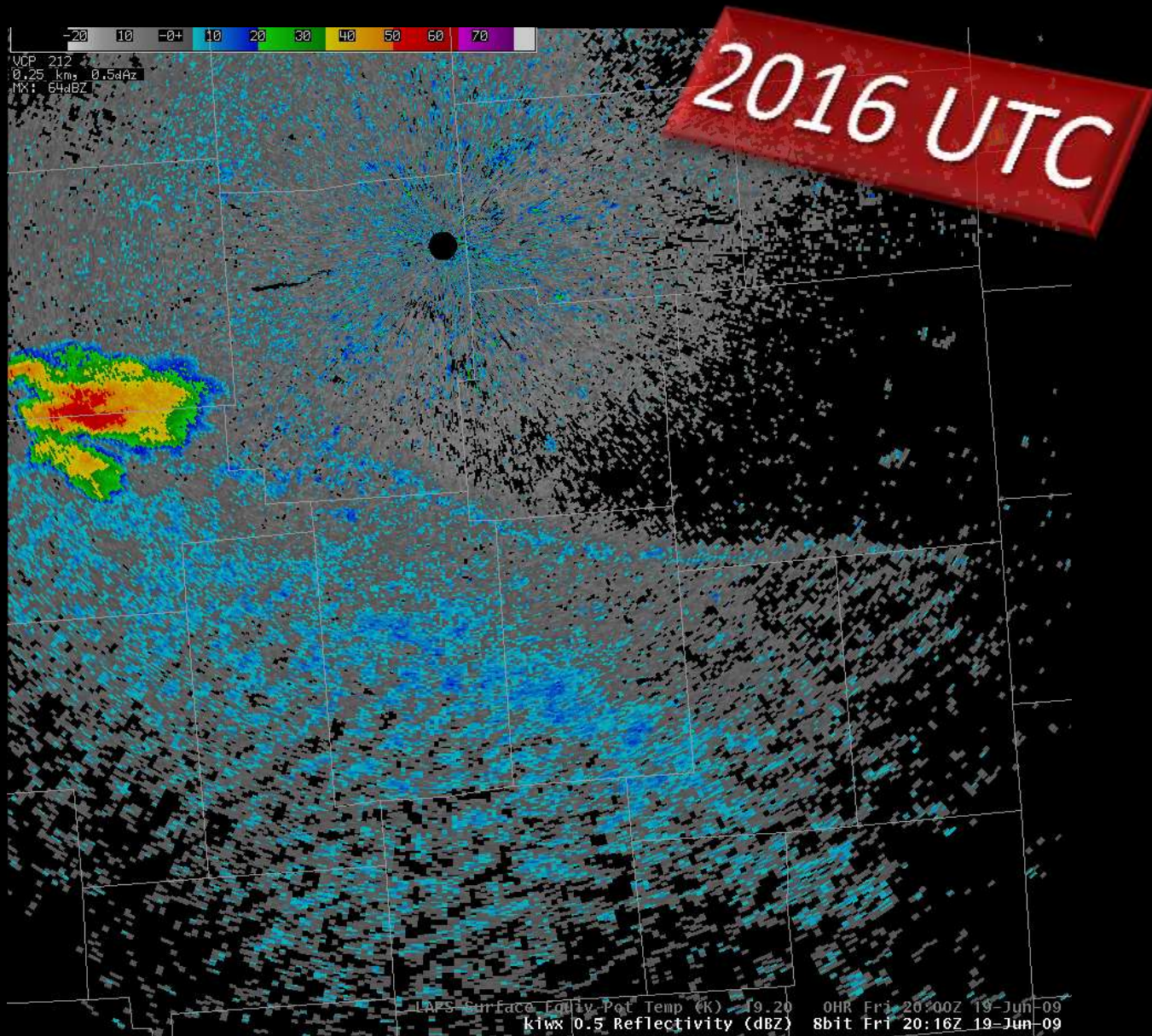
0.5 Degree Reflectivity



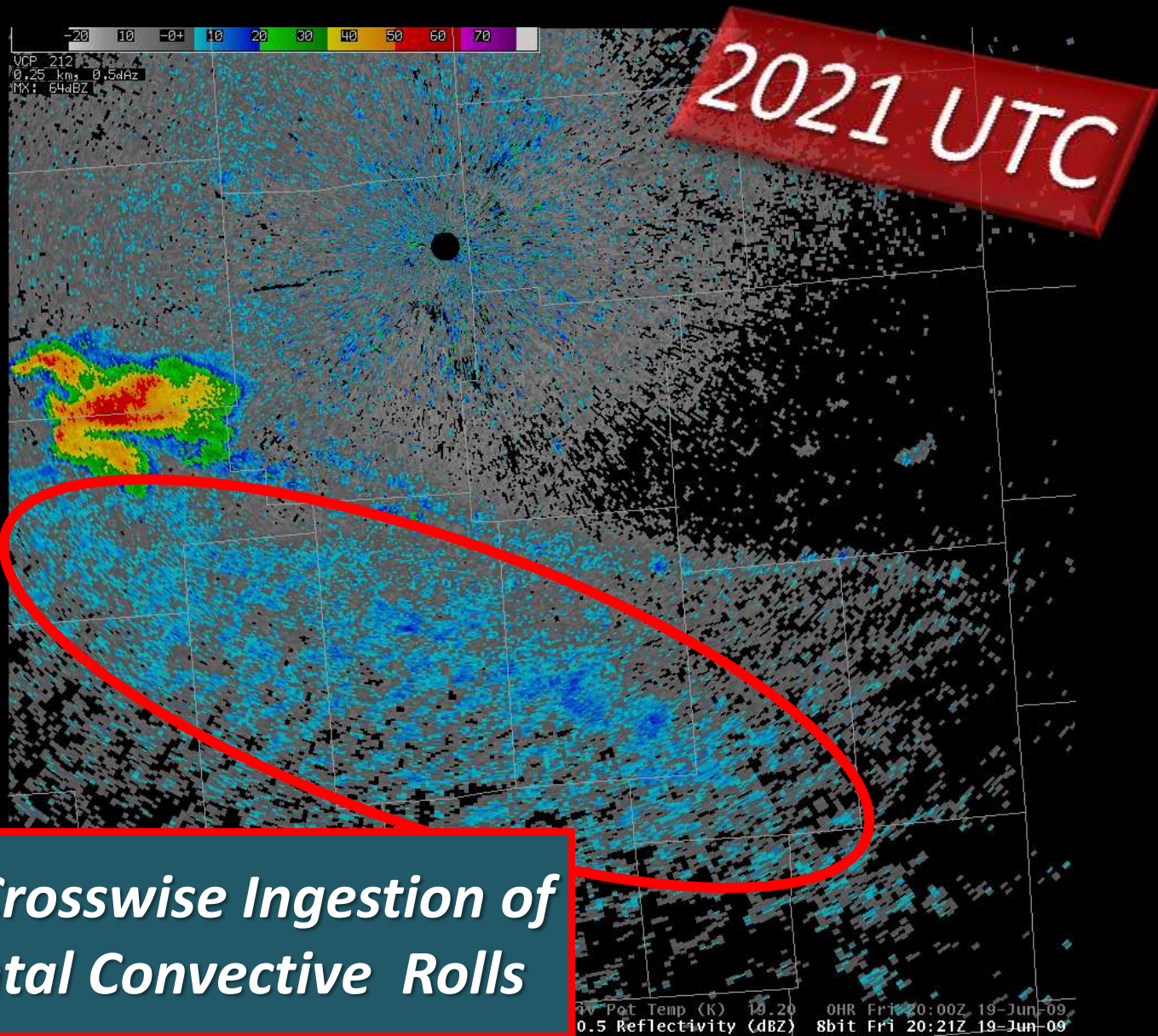
LAPS Surface Theta E & Observations



0.5 Degree Reflectivity

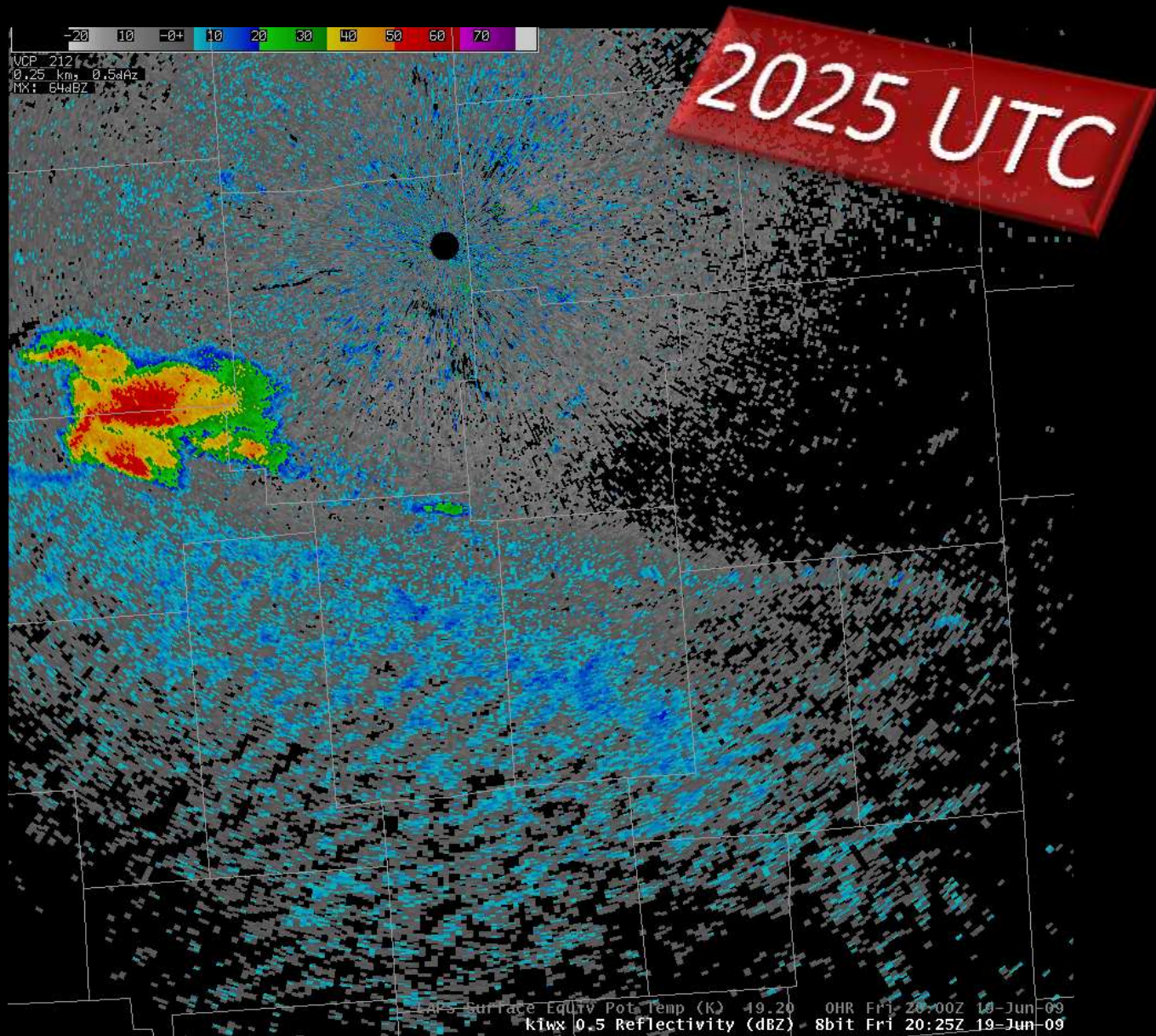


0.5 Degree Reflectivity

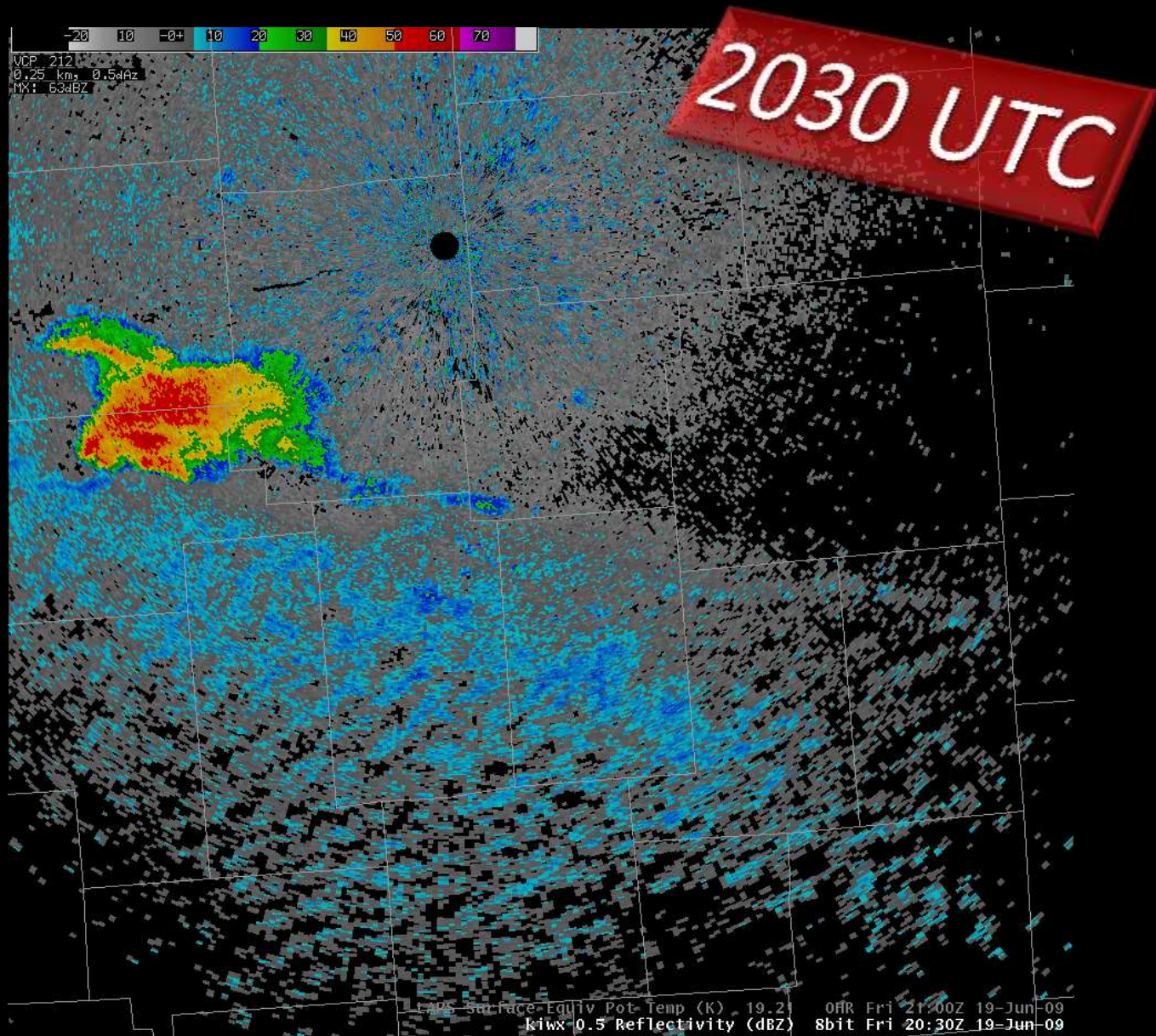


*Mainly Crosswise Ingestion of
Horizontal Convective Rolls*

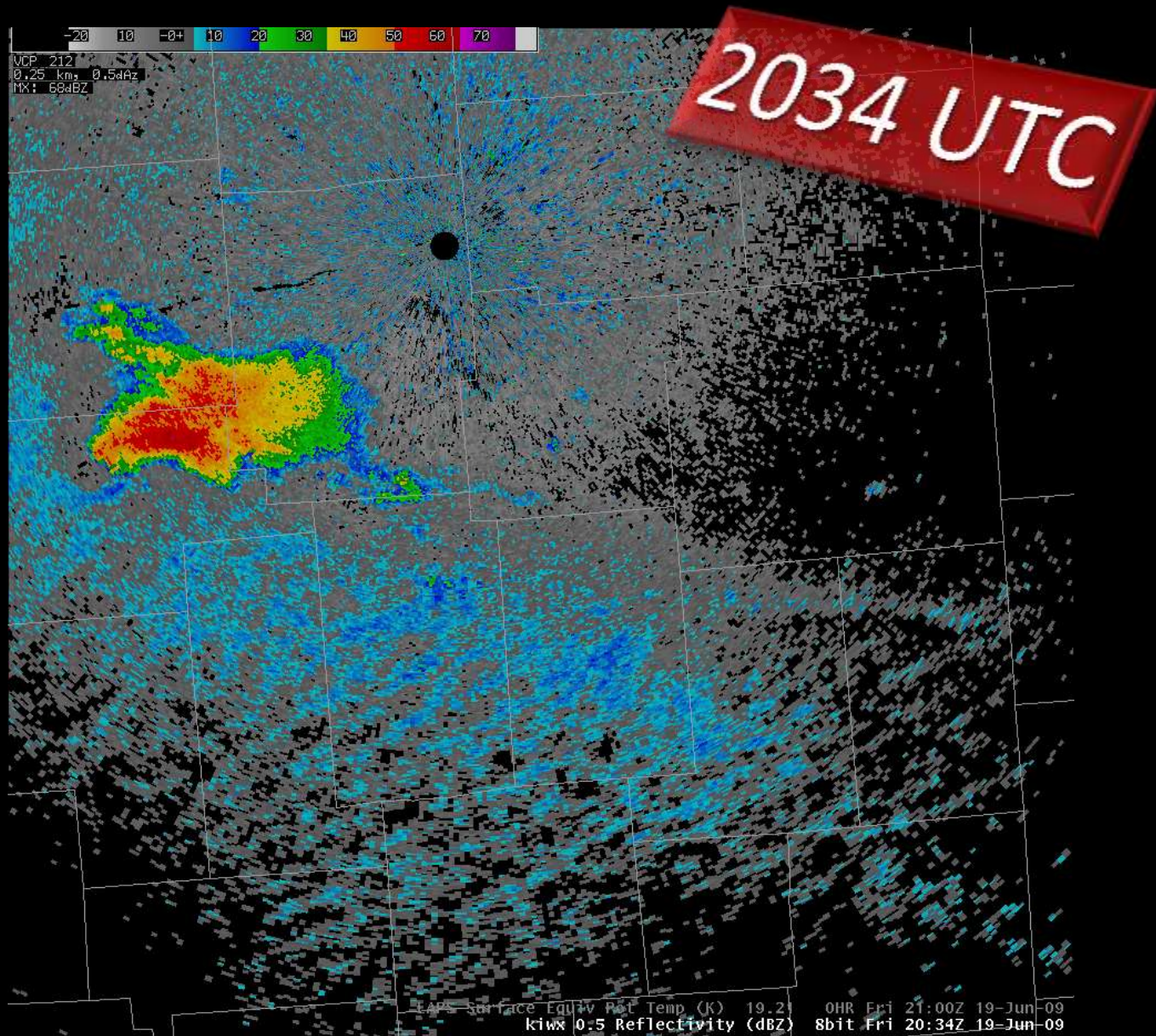
0.5 Degree Reflectivity



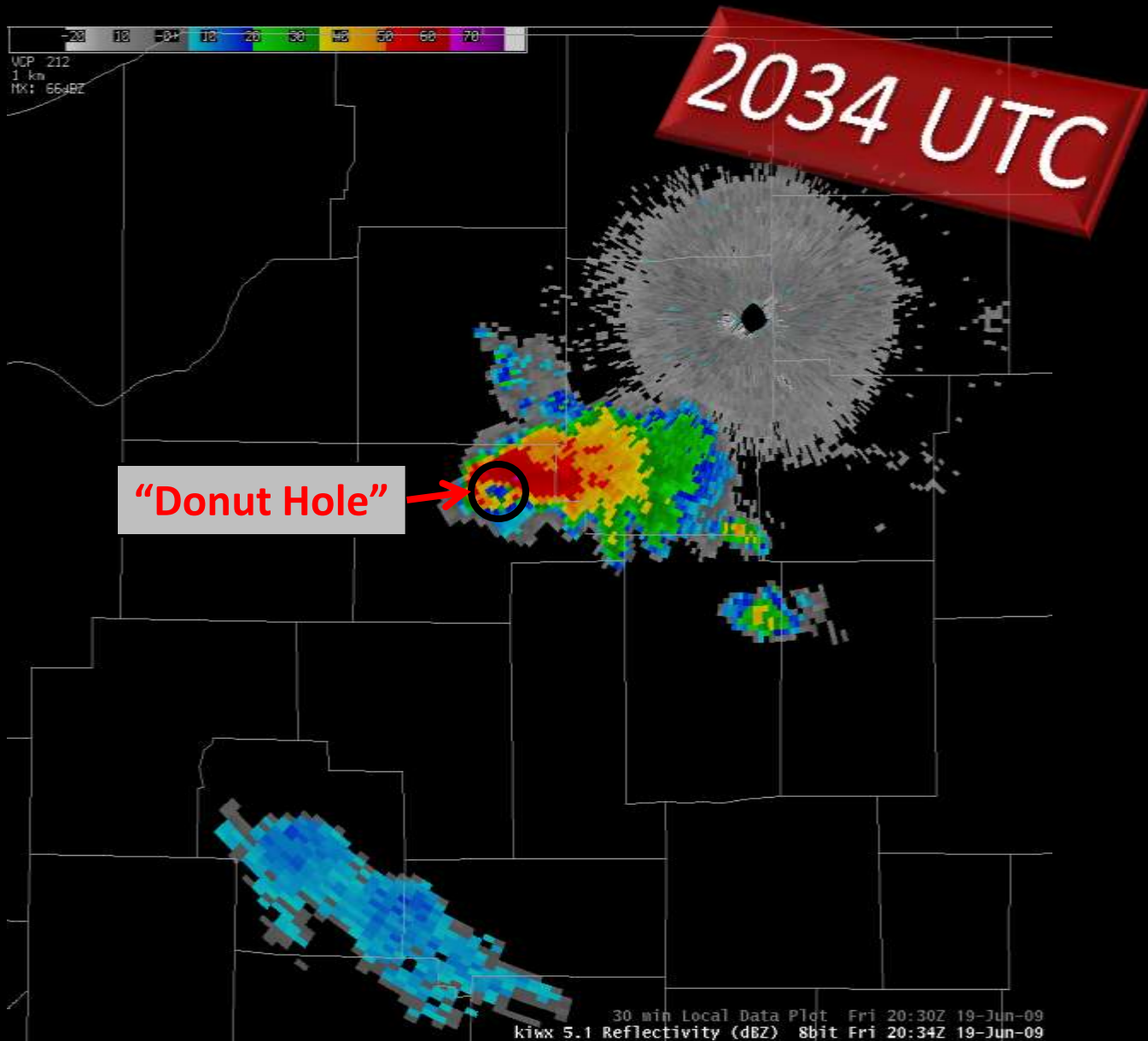
0.5 Degree Reflectivity



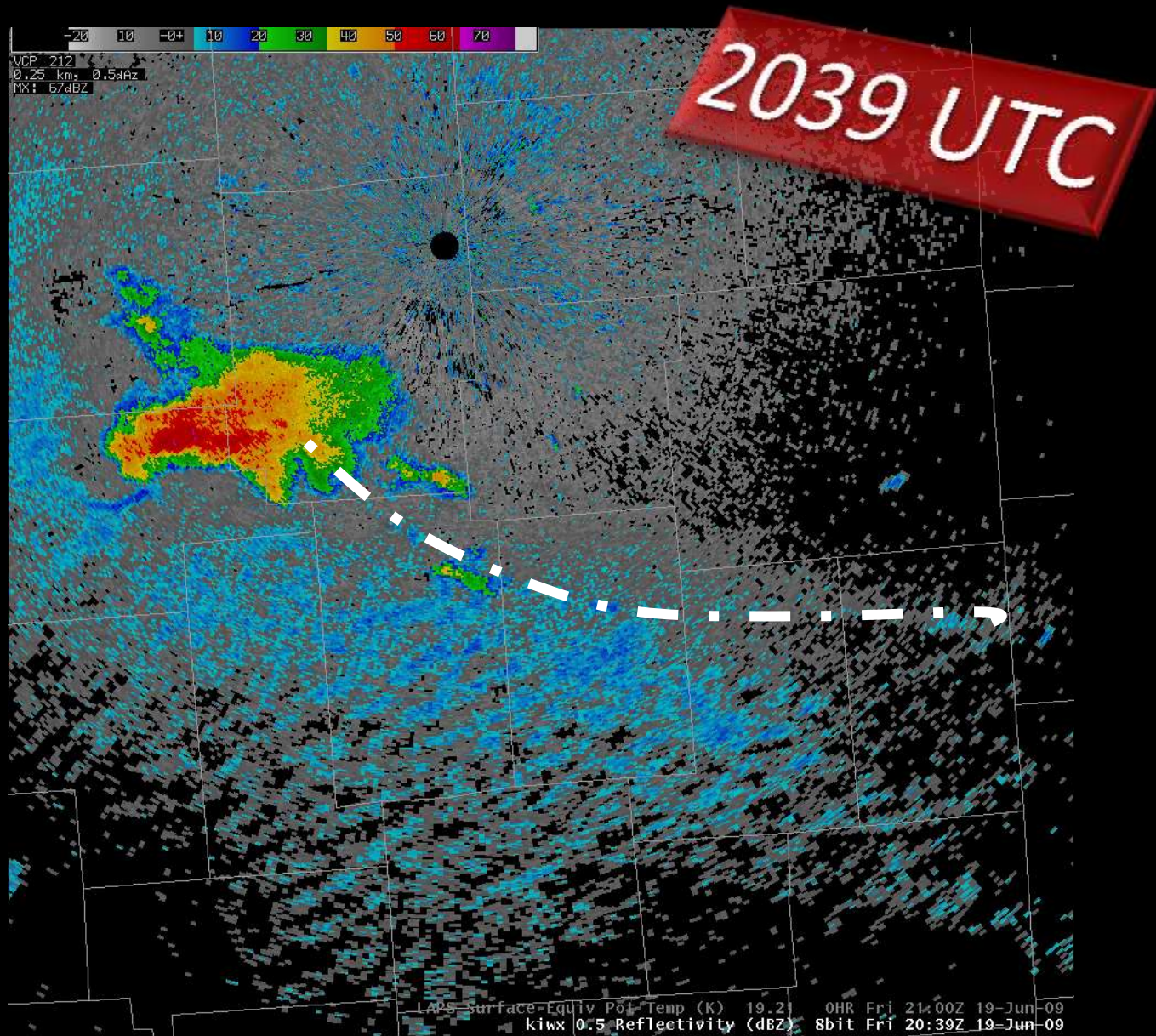
0.5 Degree Reflectivity



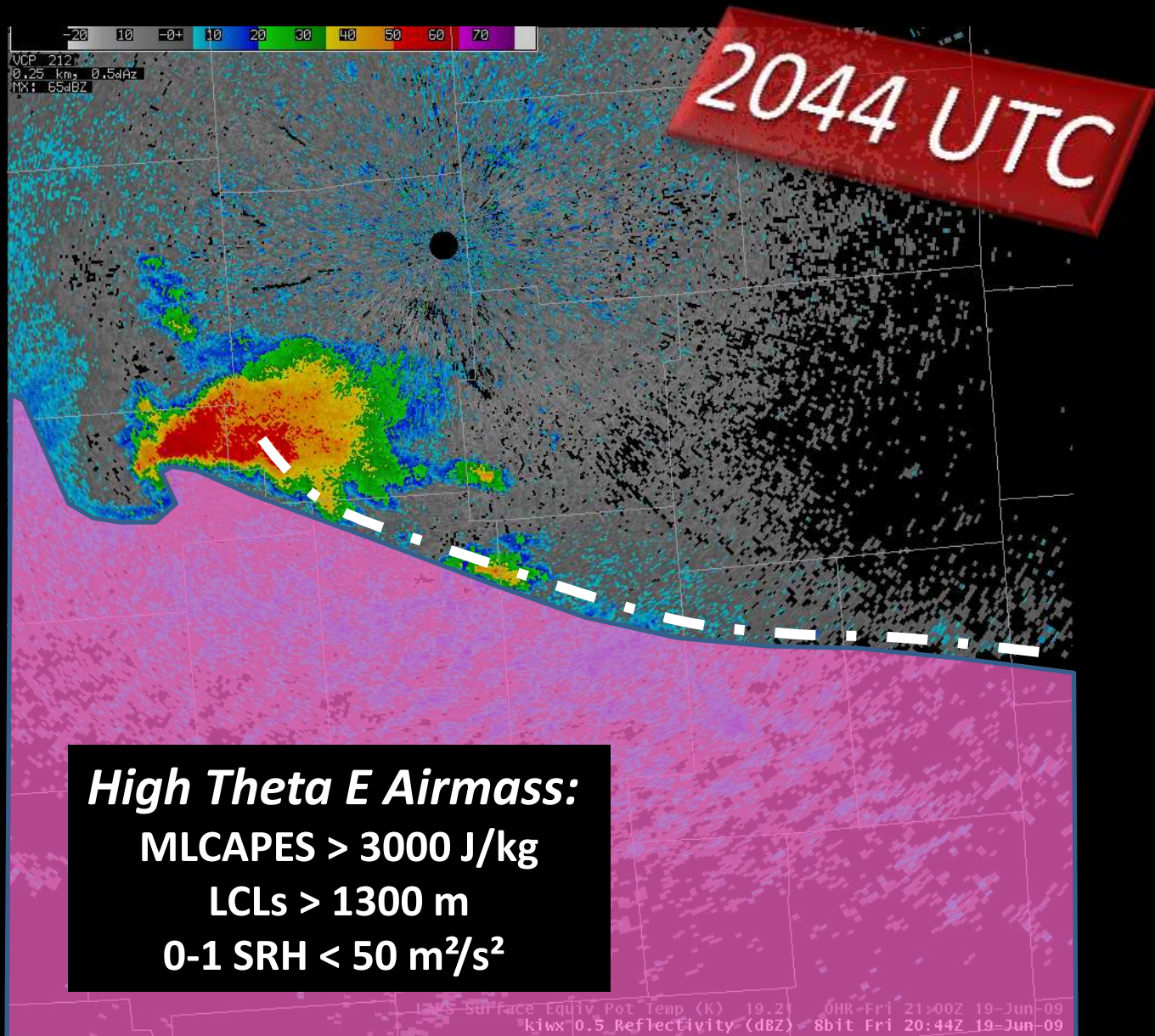
5.1 Degree Reflectivity



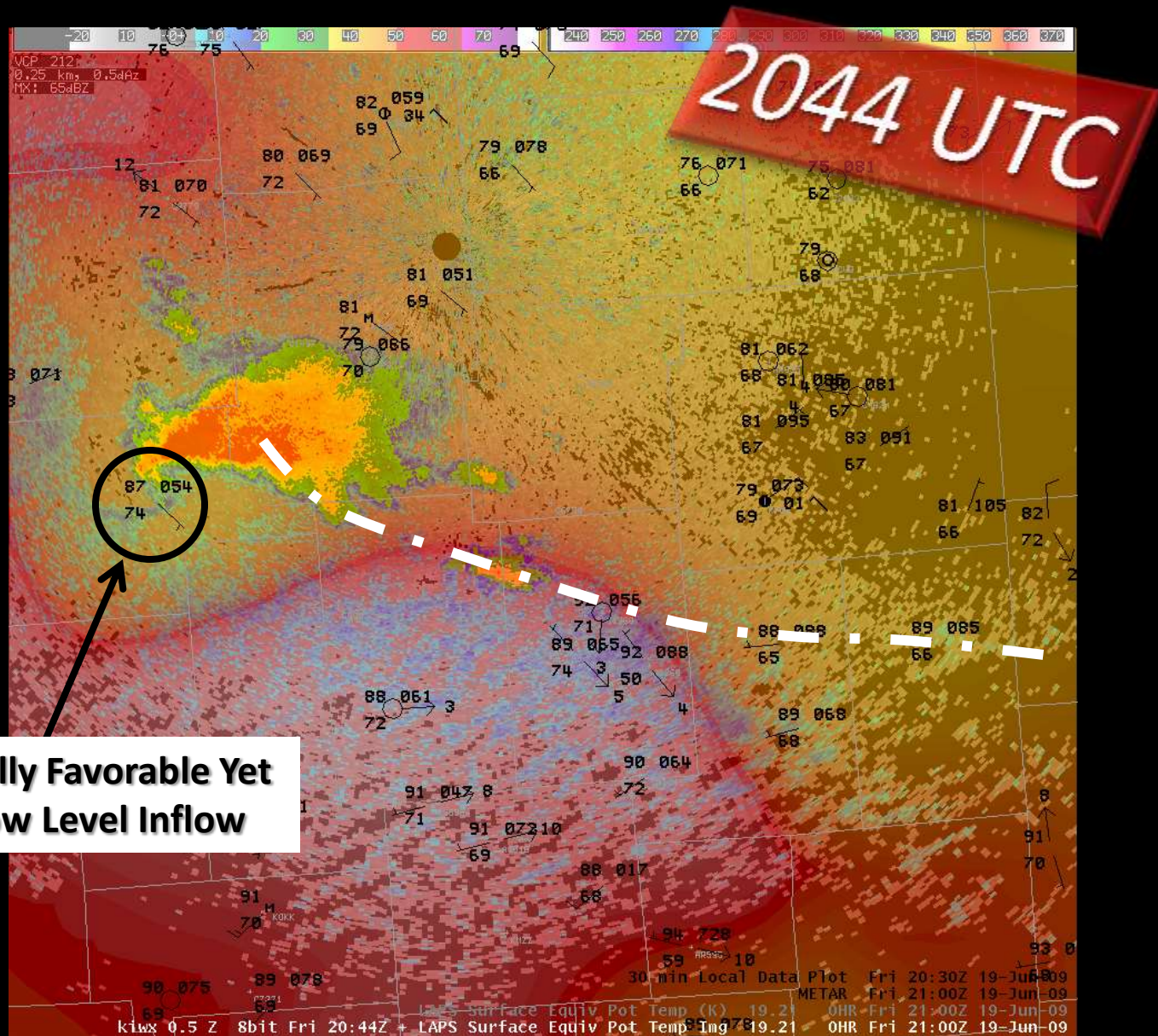
0.5 Degree Reflectivity



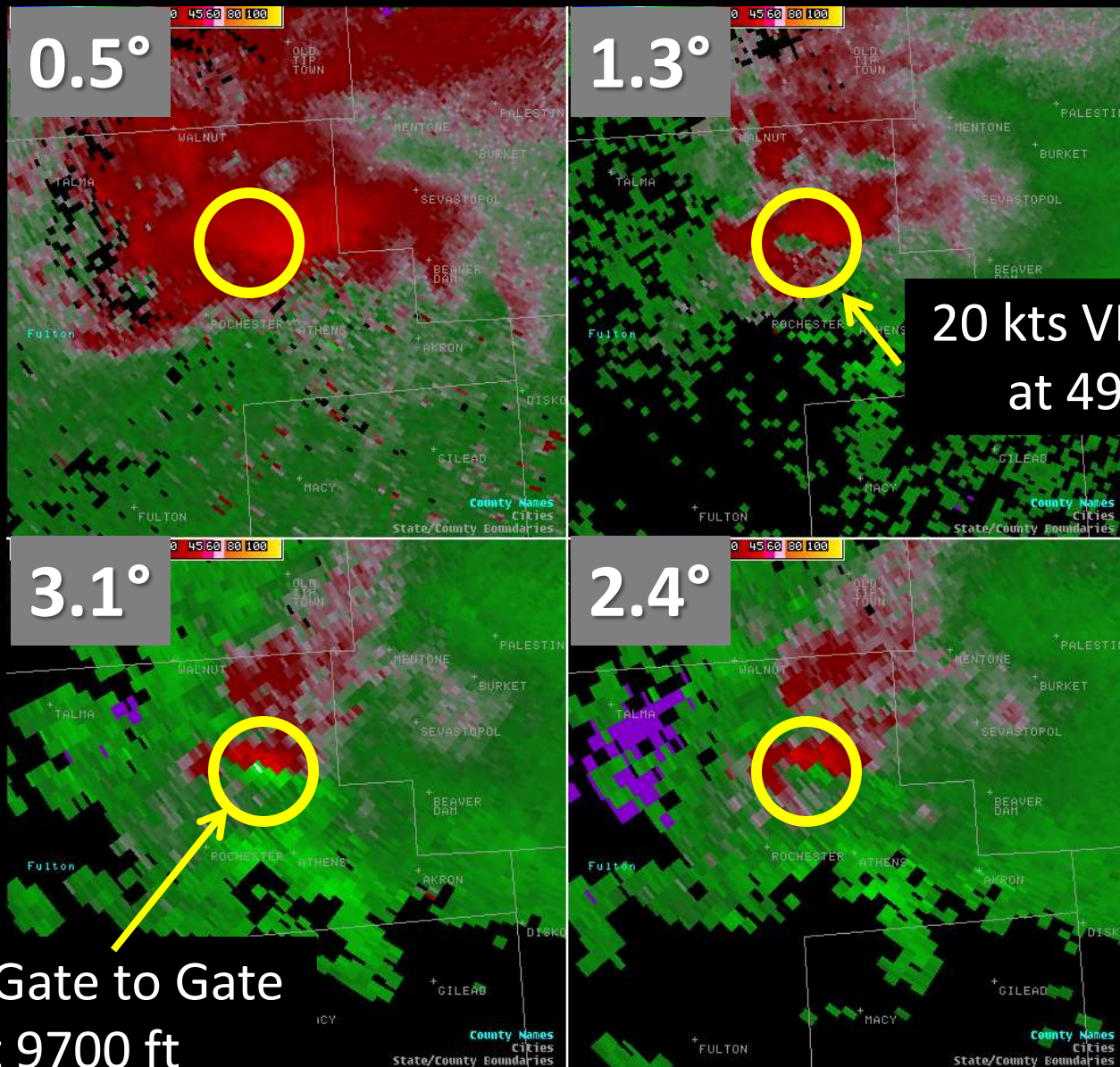
0.5 Degree Reflectivity



LAPS Surface Theta E & Observations



2044 UTC Storm Relative Motion



20 kts VR-Shear
at 4900 ft

87 kts Gate to Gate
at 9700 ft

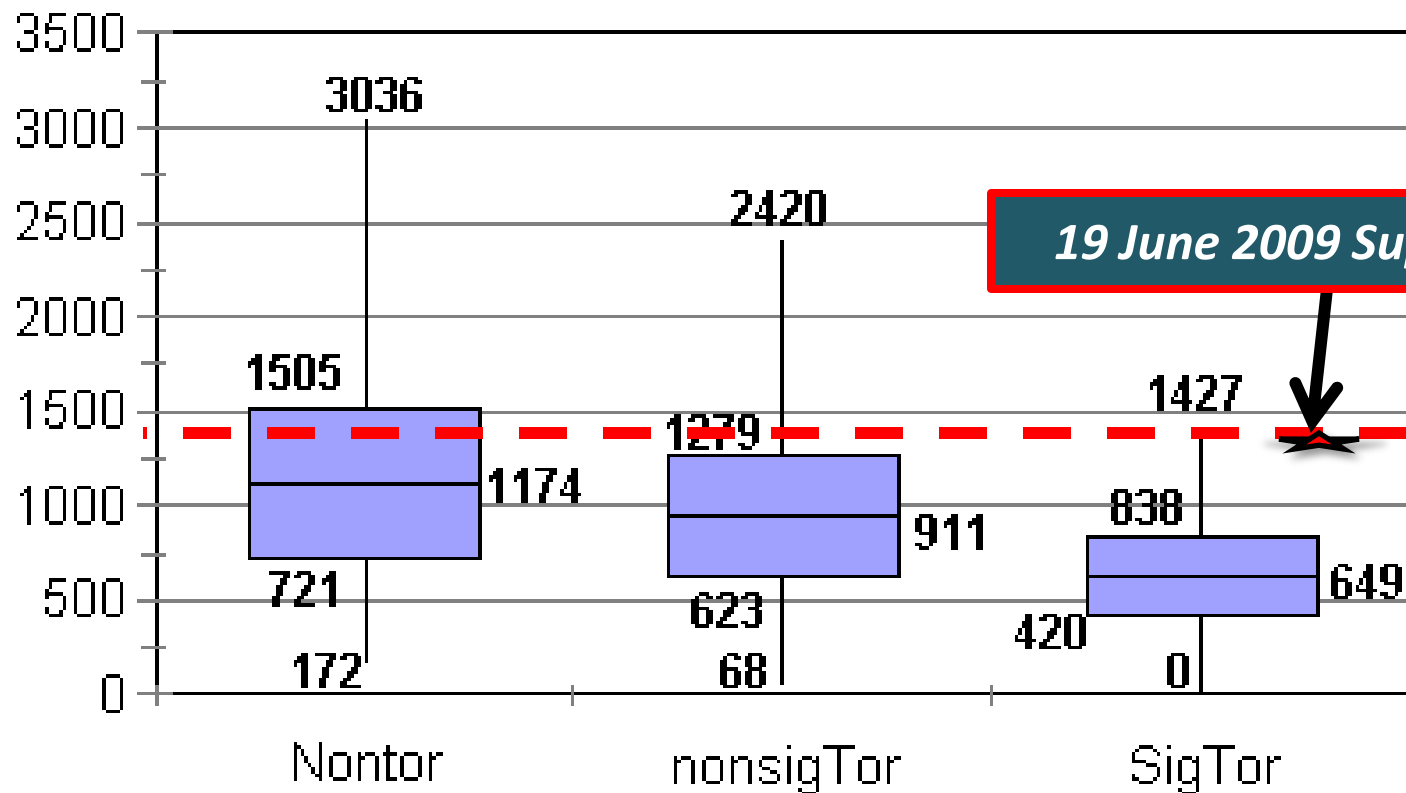


Why No Tornado Yet?

- 3 Main Reasons:
 - Storm was still organizing, mid level mesocyclone had not built down toward surface
 - Ambient low level SRH/0-1 km shear values were not impressive
 - LCLs were near 1400 meters on the south side of the boundary

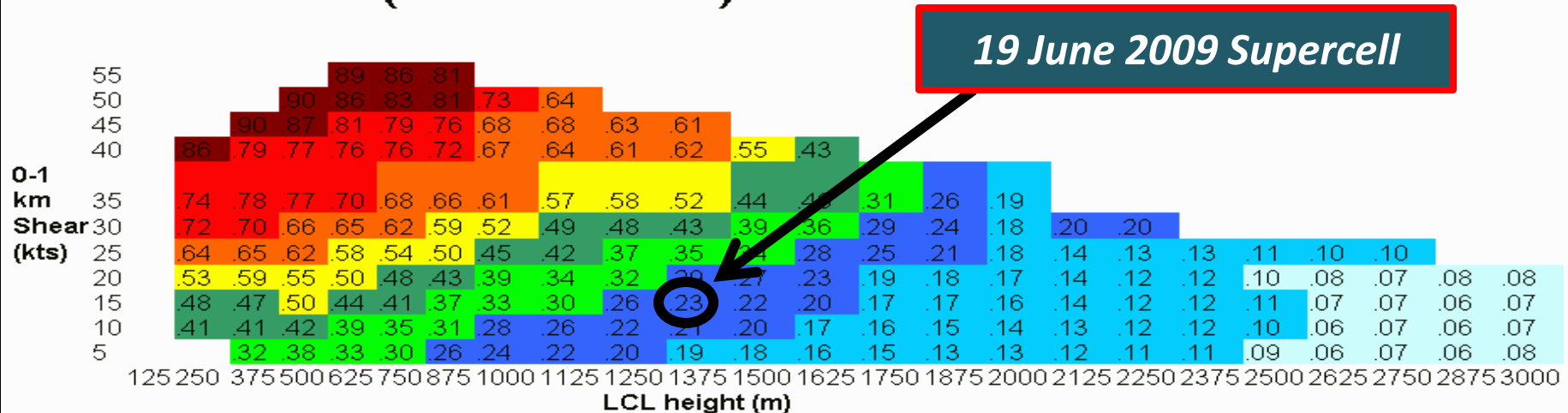
LCL Importance

surface parcel LCL heights

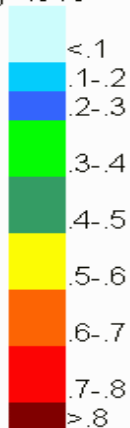


0-1 km Shear vs. LCL heights

Probability of tornado (1973-1993)



Overall climatological frequency=.313



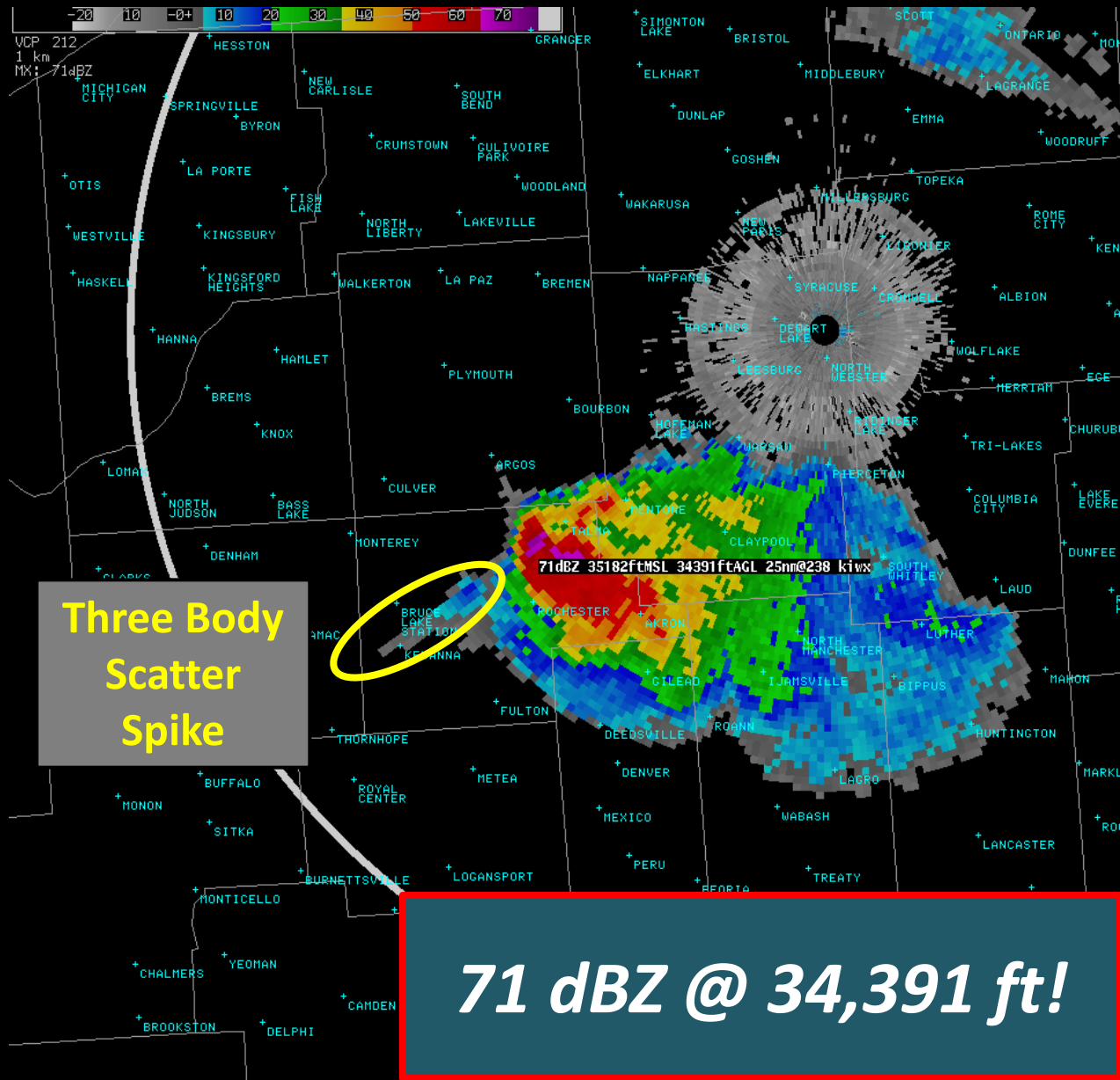
Filled elements have at least 30 soundings

Numbers at each cell found by:

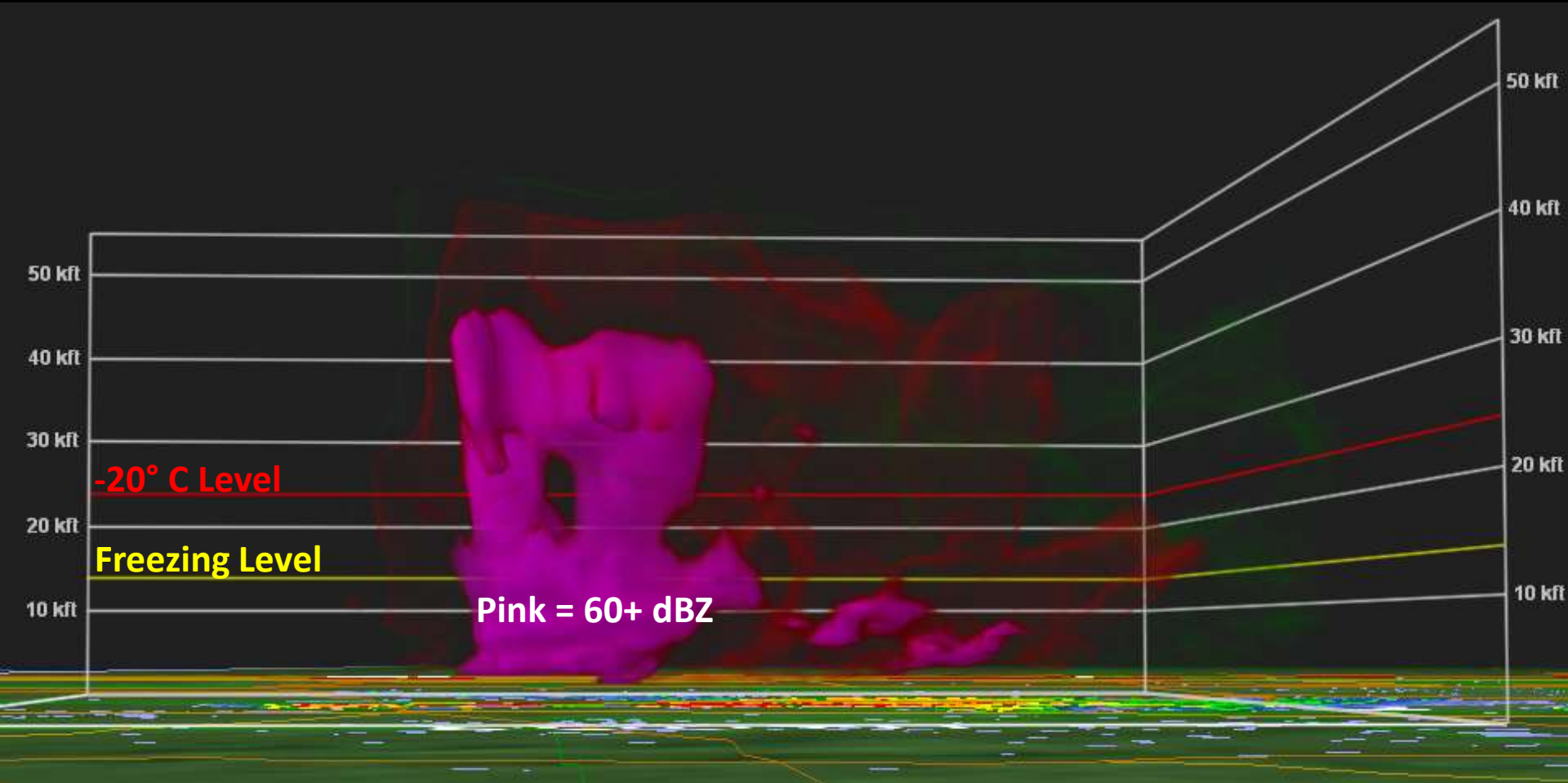
- 1) Divide LCL by 25
- 2) Compute "distance" from cell value $\text{SQRT}((\text{LCL}/25-x)^2 + (\text{Shear}-y)^2)$
- 3) If distance < 15, point included
- 4) Tornadoic soundings/total soundings at cell gives value

Brooks and Craven 2002

Any Hail in this Storm??



How 'Bout this Core?



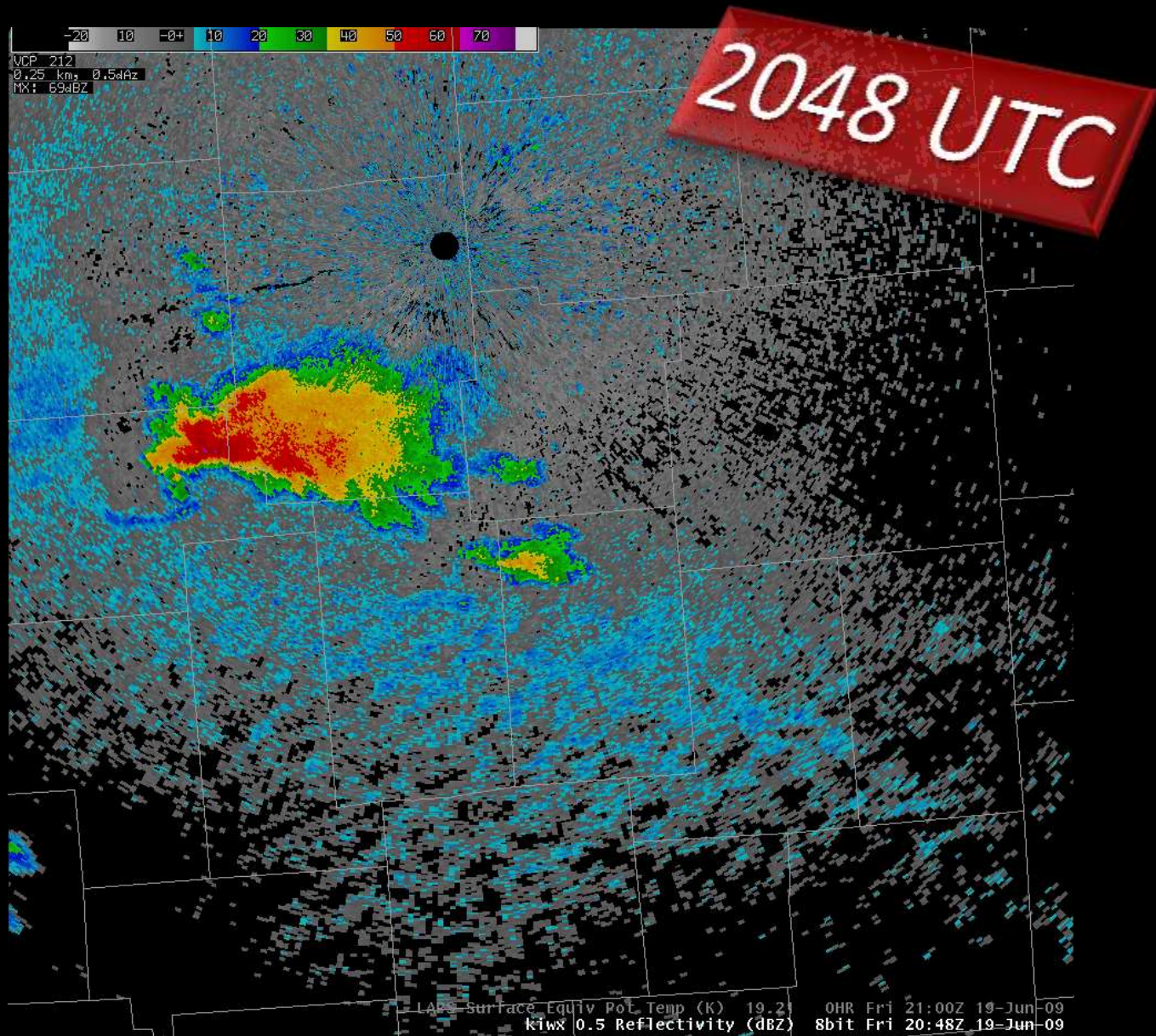
This Storm had 53 dBZ @ 52,400 feet!

BAM!

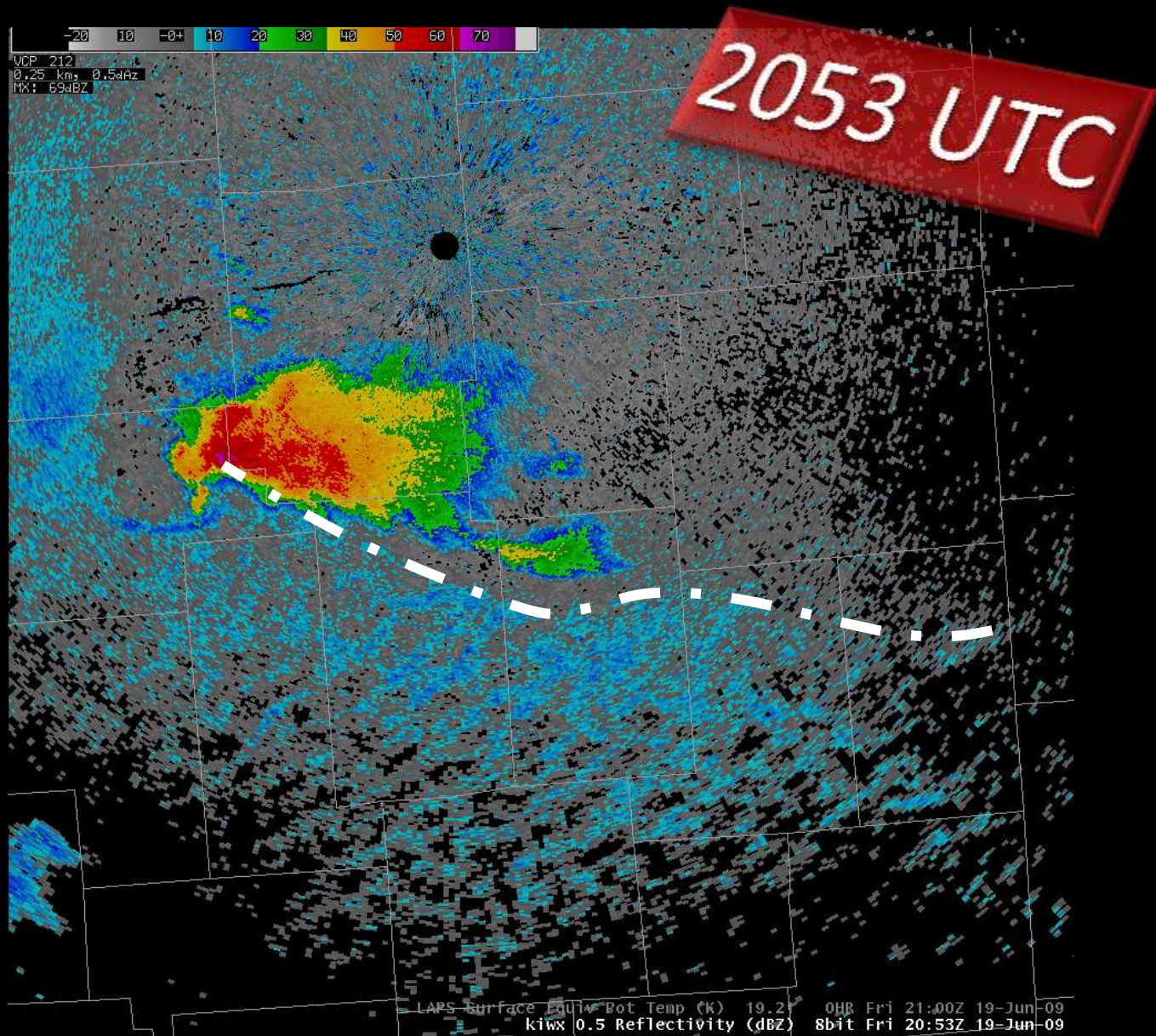


Photo Courtesy: Thomas Hayden

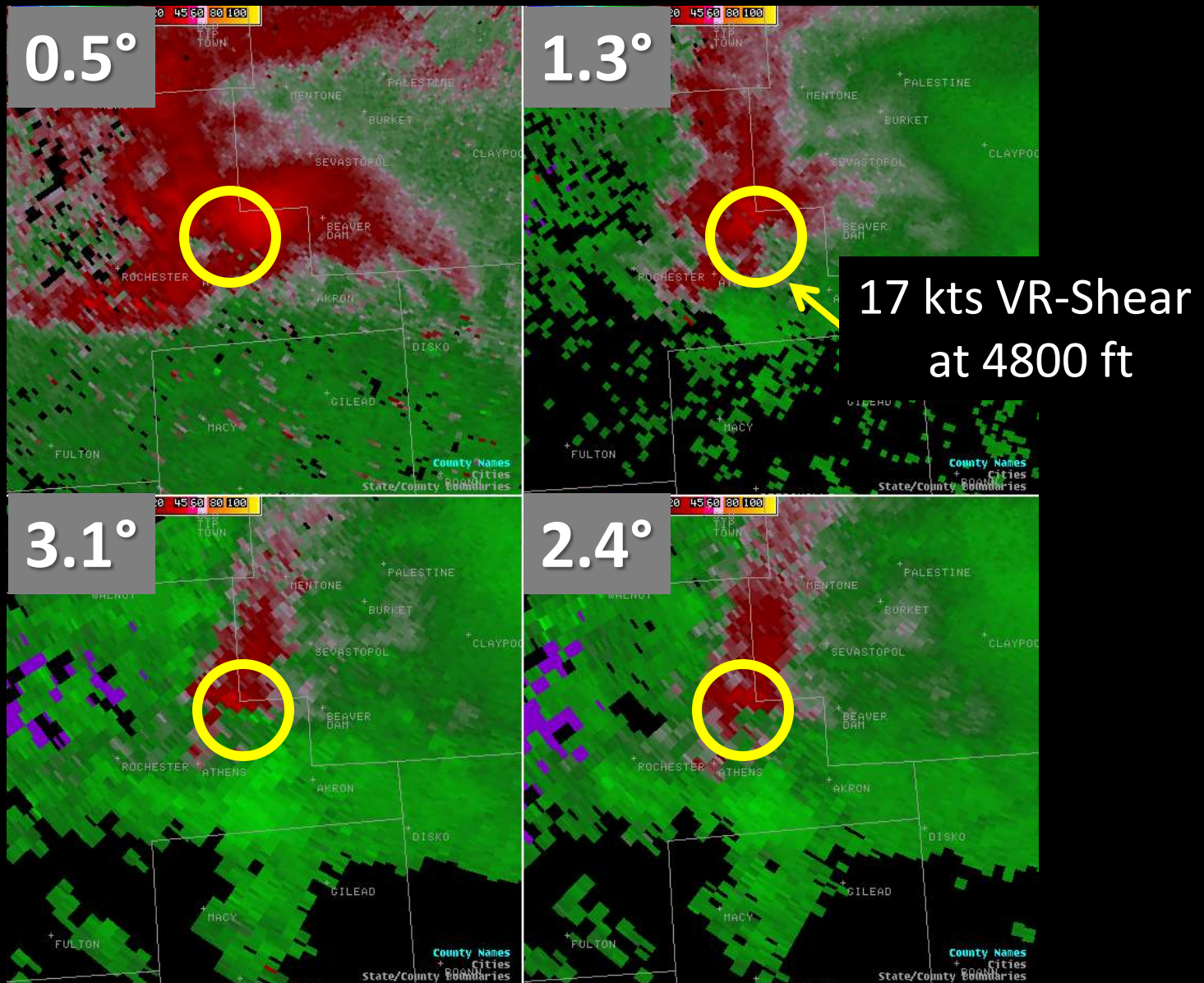
0.5 Degree Reflectivity



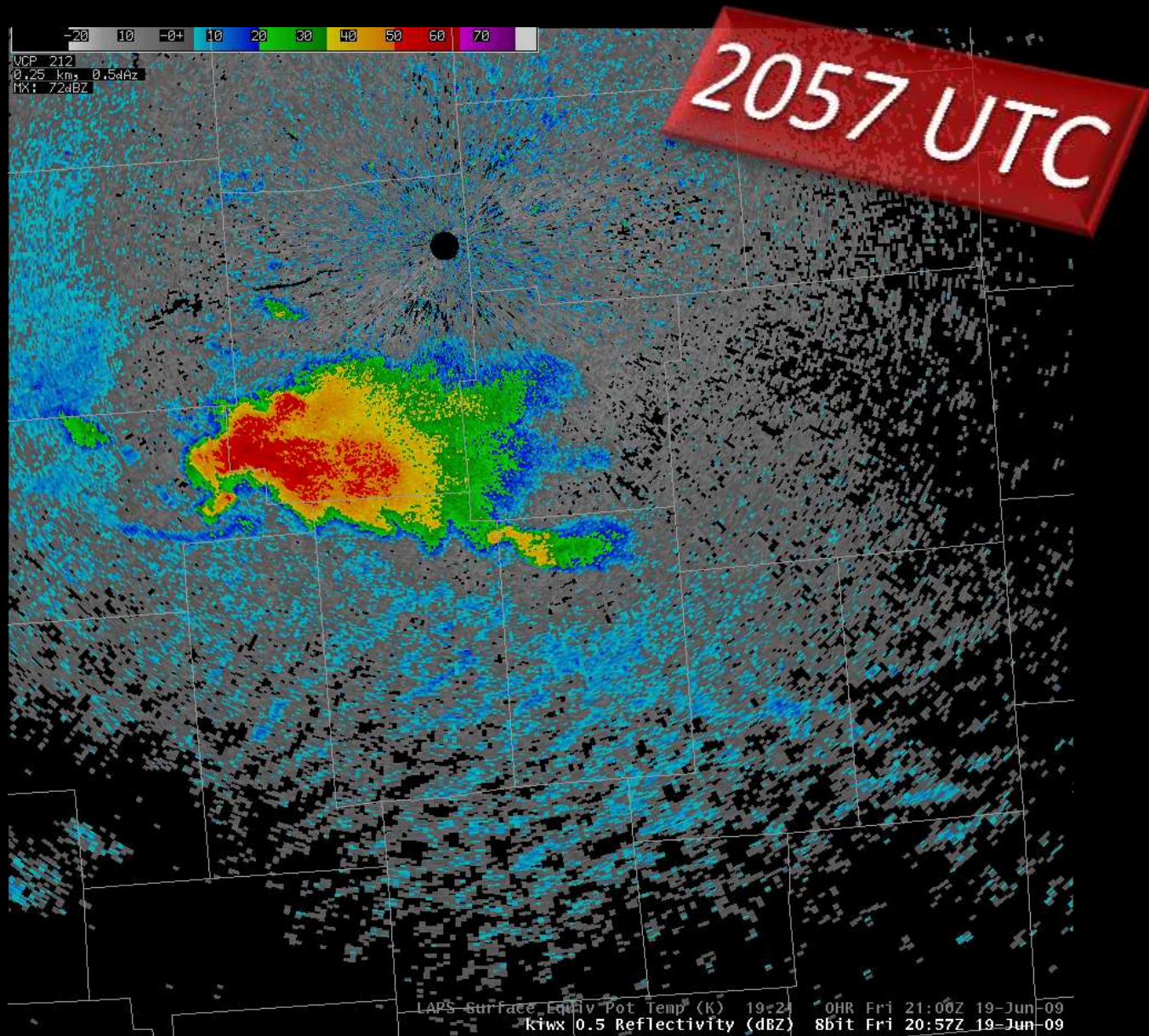
0.5 Degree Reflectivity



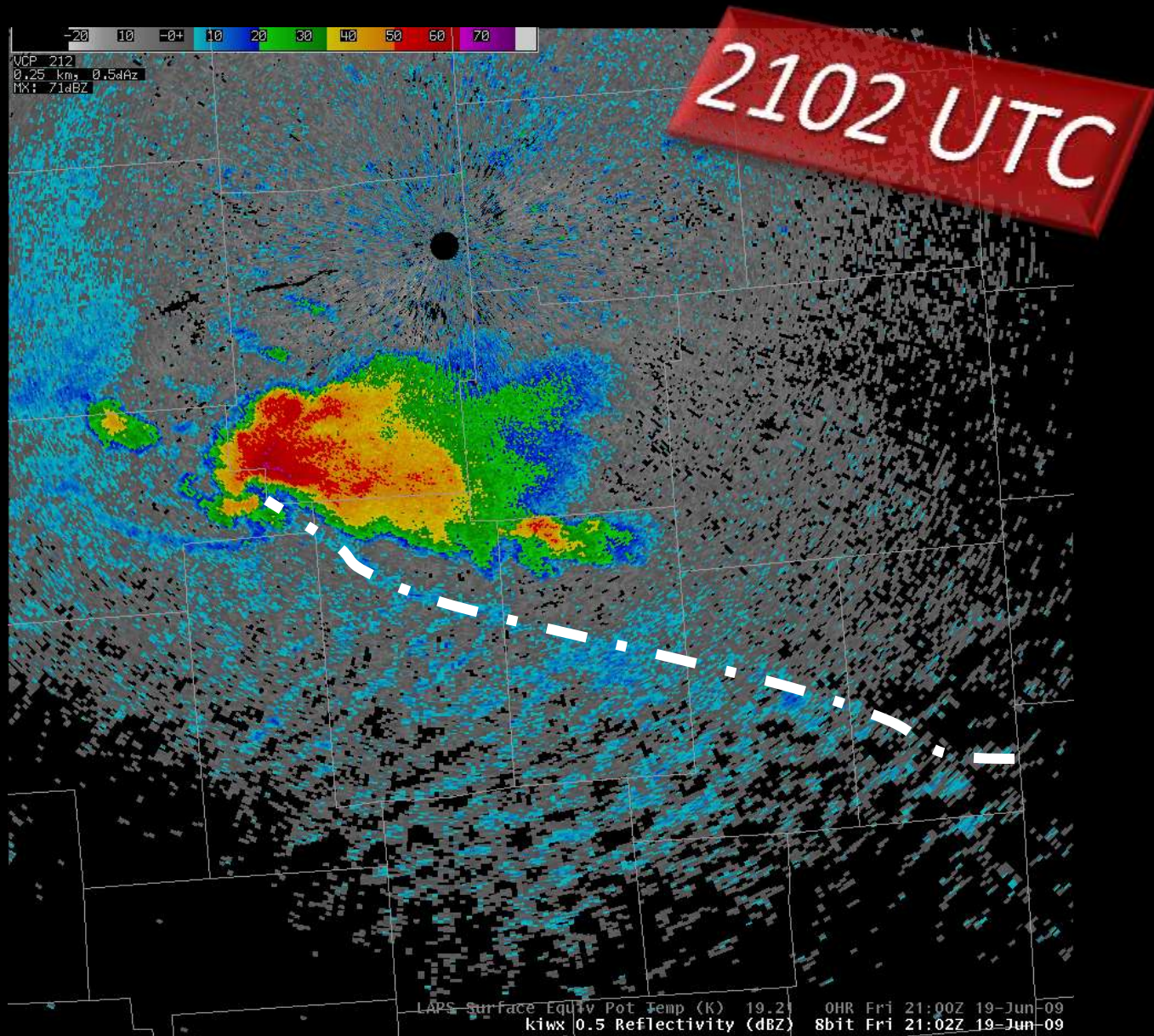
2053 UTC Storm Relative Motion



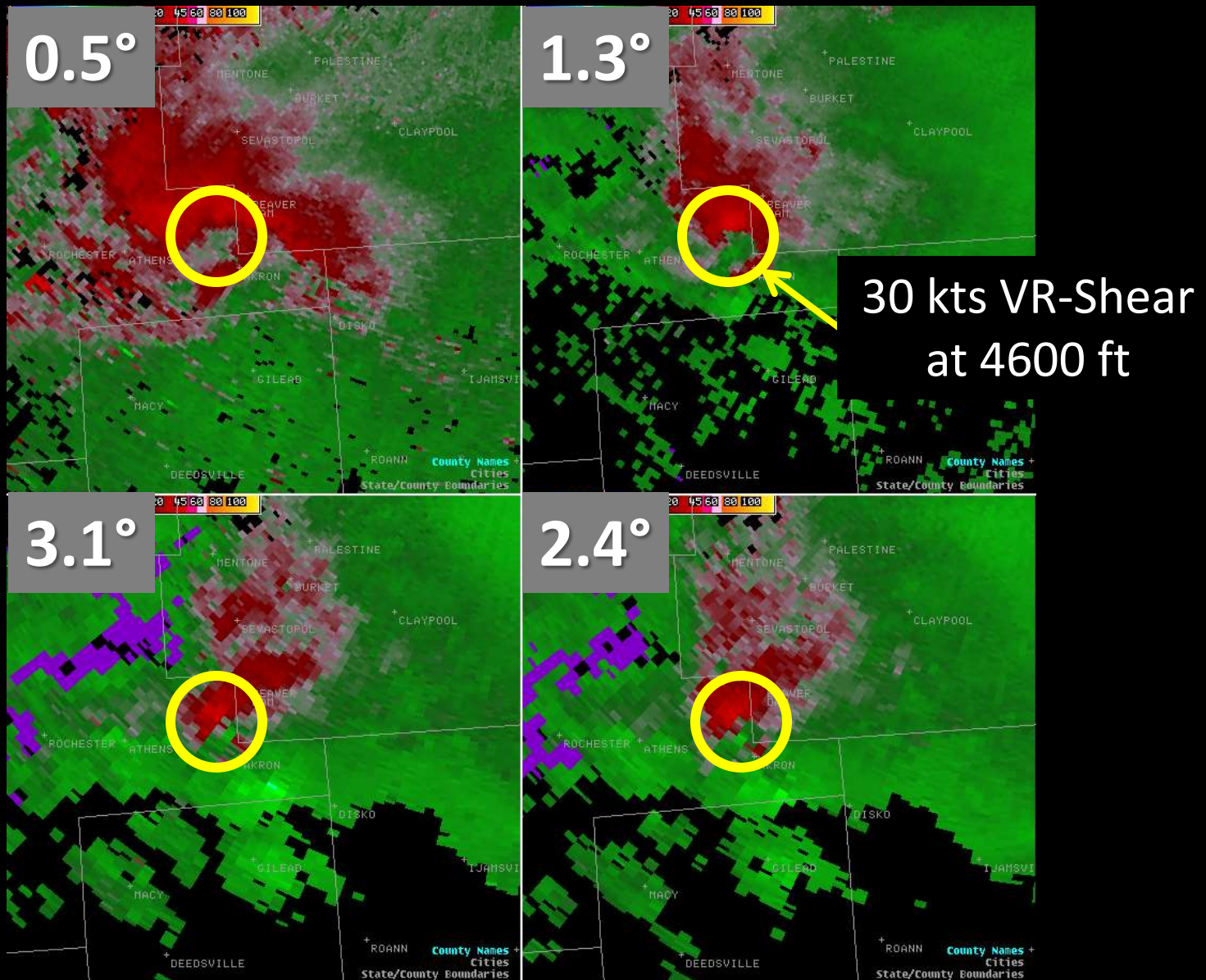
0.5 Degree Reflectivity



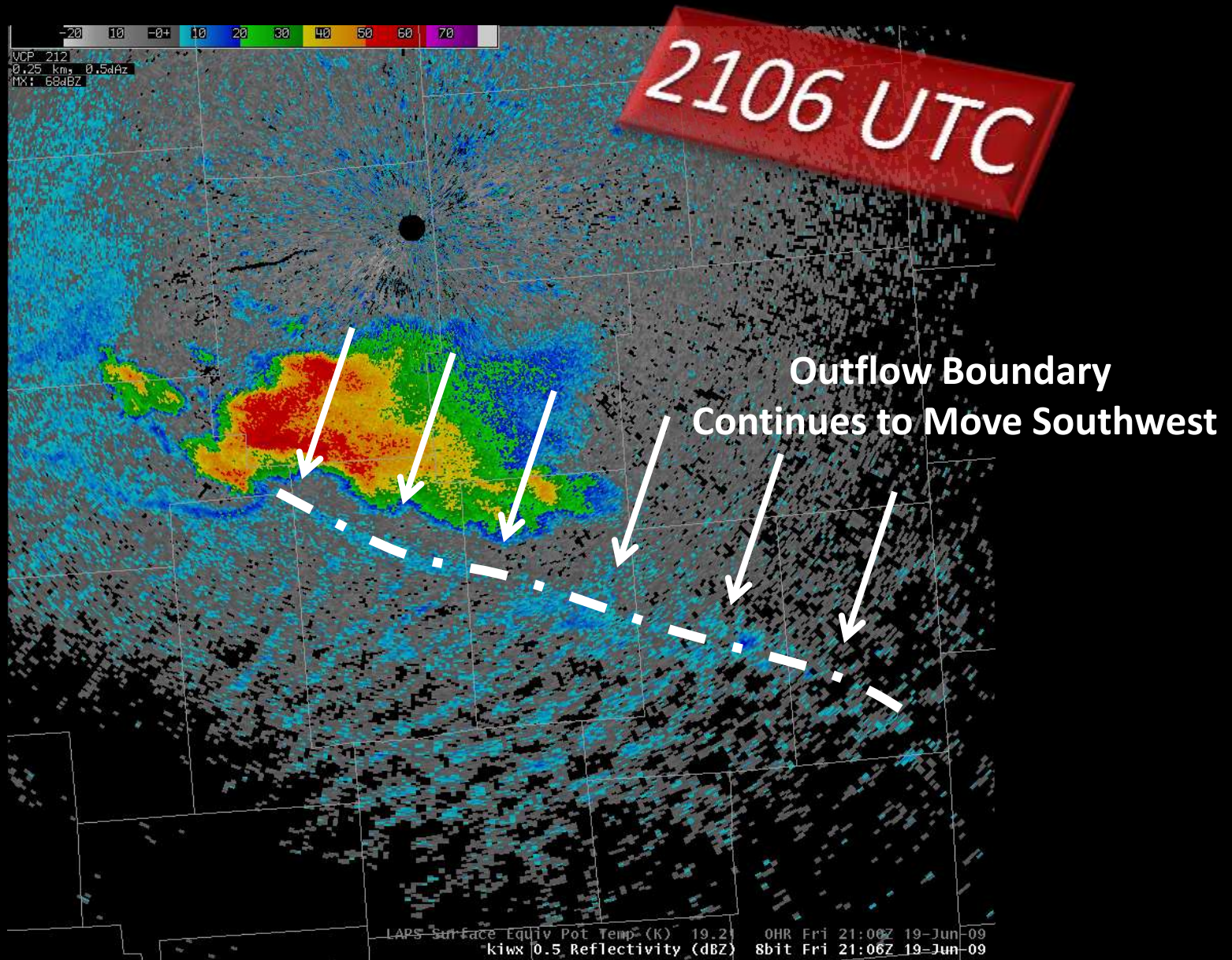
0.5 Degree Reflectivity



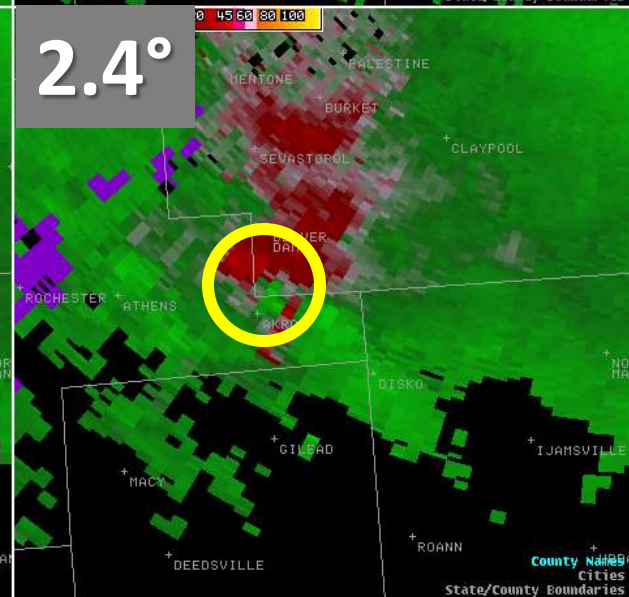
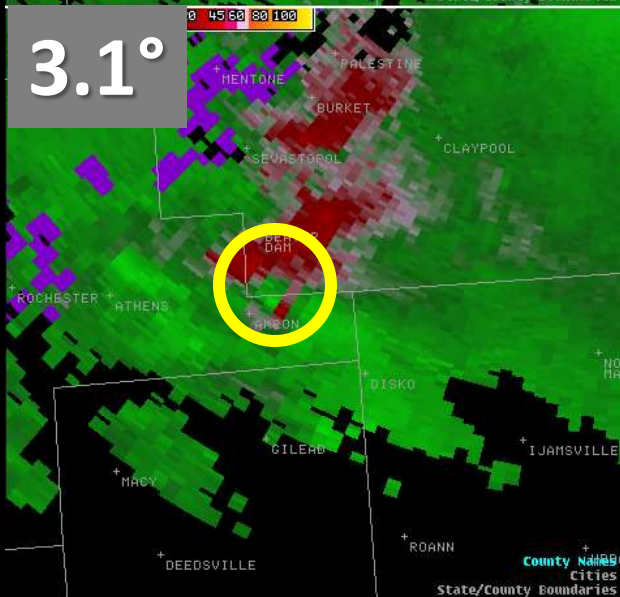
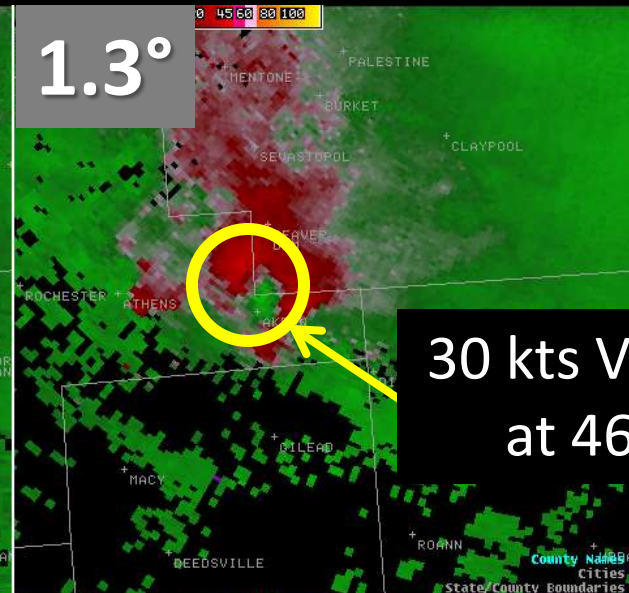
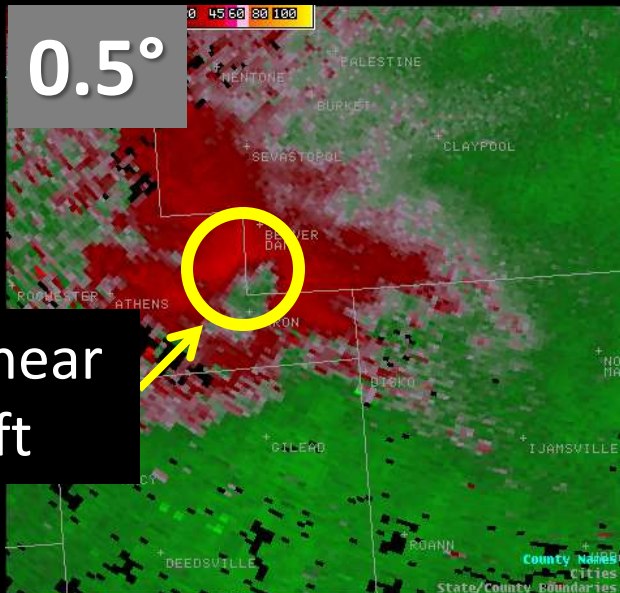
2102 UTC Storm Relative Motion



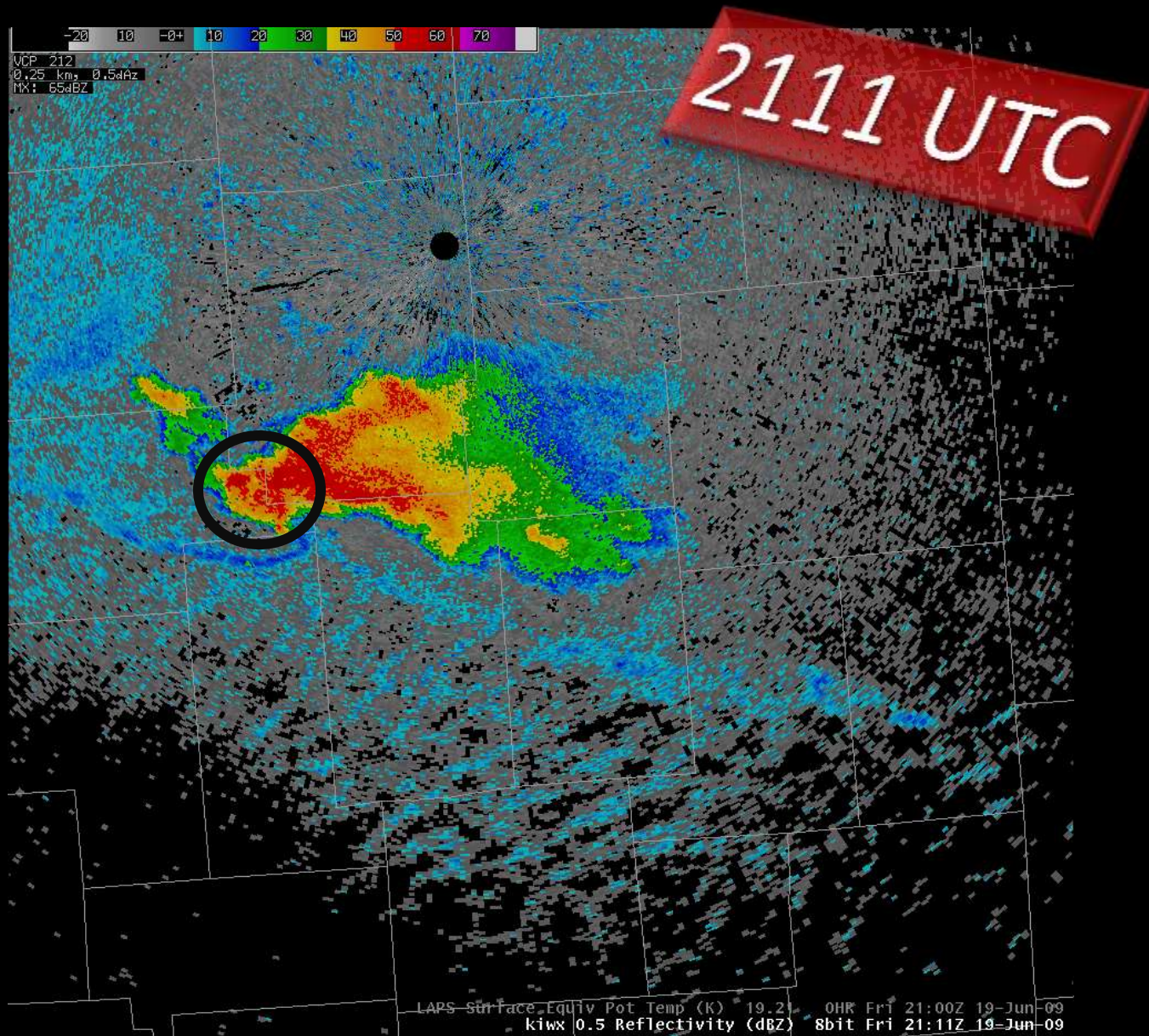
0.5 Degree Reflectivity



2106 UTC Storm Relative Motion



0.5 Degree Reflectivity



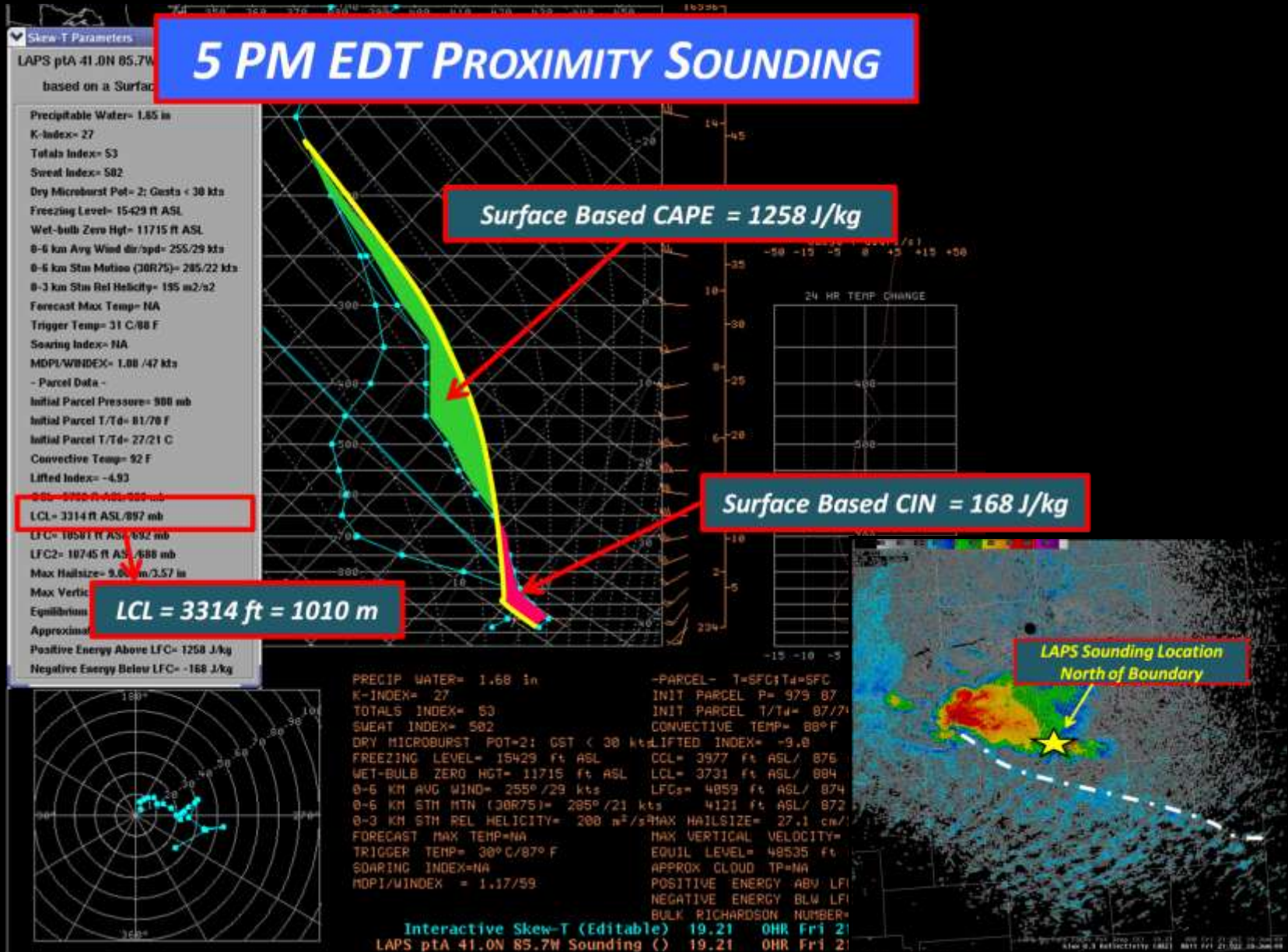


Storm Crosses Boundary

- Now this supercell will exist in an entirely different environment
- An environment characterized by:
 - Enhanced horizontal vorticity generated by outflow boundary
 - Much lower LCLs
 - However...Much lower CAPE values

LAPS Proximity Sounding

(Adjusted to Reflect Surface Conditions North of the Boundary)



Conceptual Model: Storm Crossing Boundary

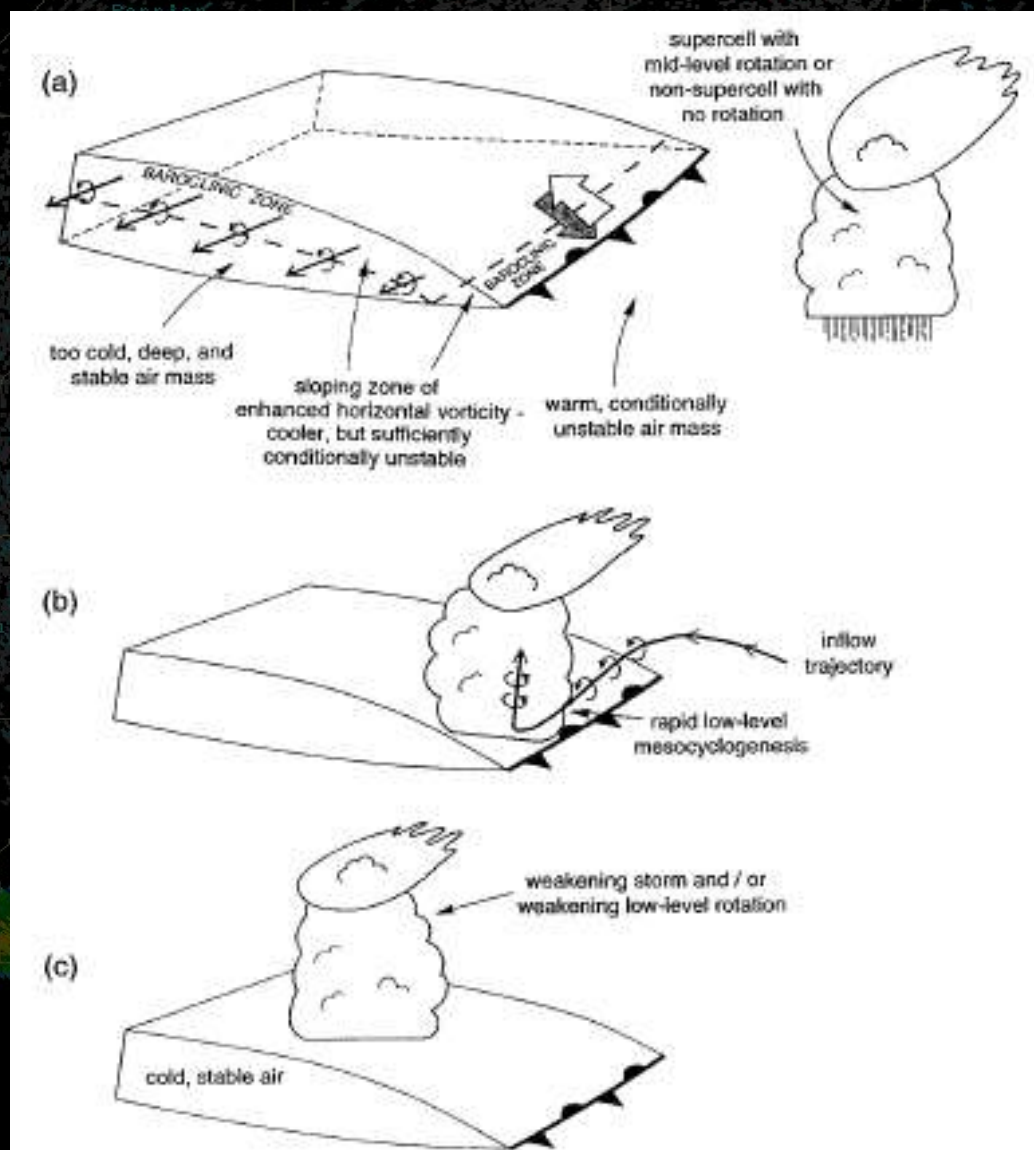
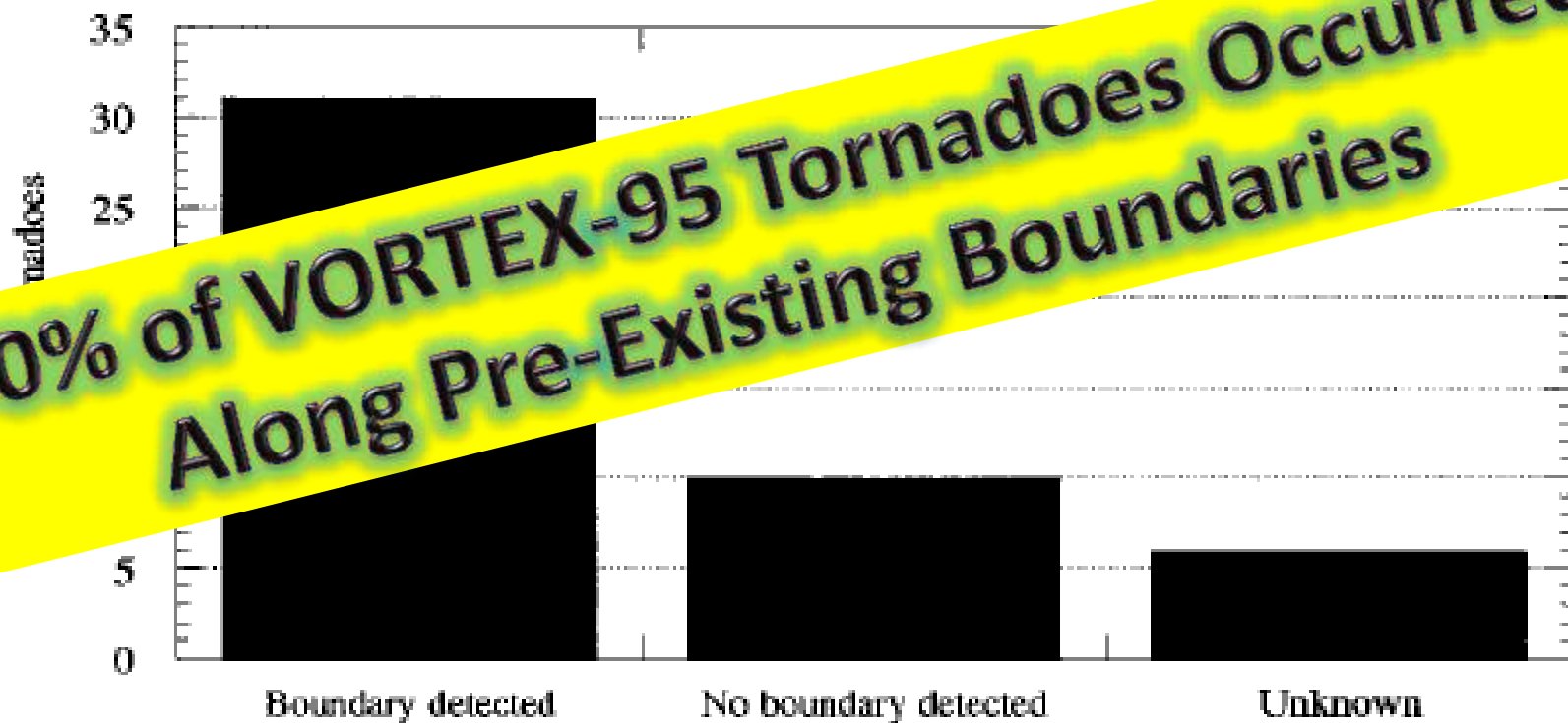


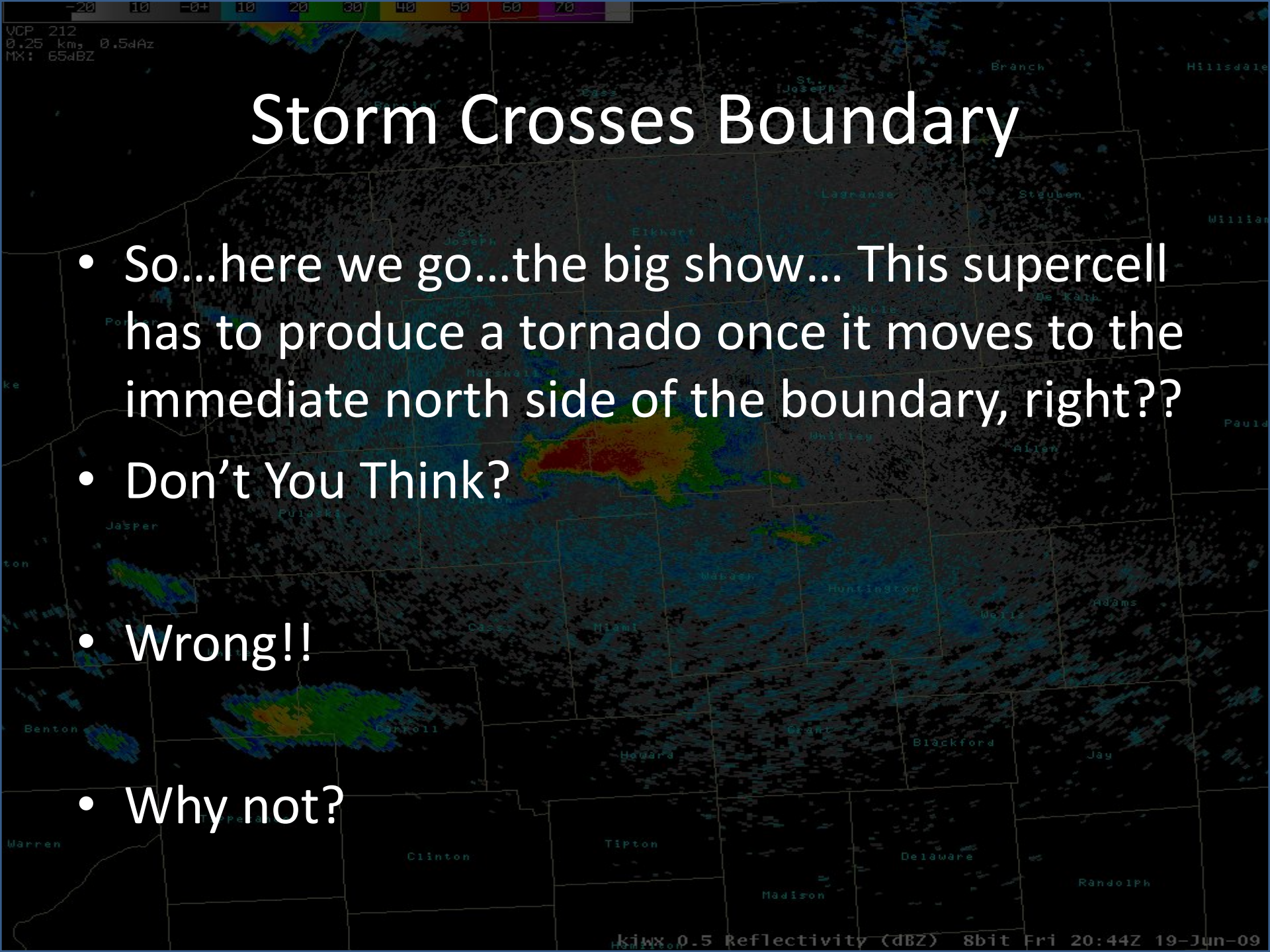
FIG. 2. A conceptual model for how an updraft-boundary interaction may lead to low-level mesocyclogenesis.

Markowski, et al. (1998)

Boundary Related Research

**Frequency of Boundary Presence
Near VORTEX-95 Tornadoes**

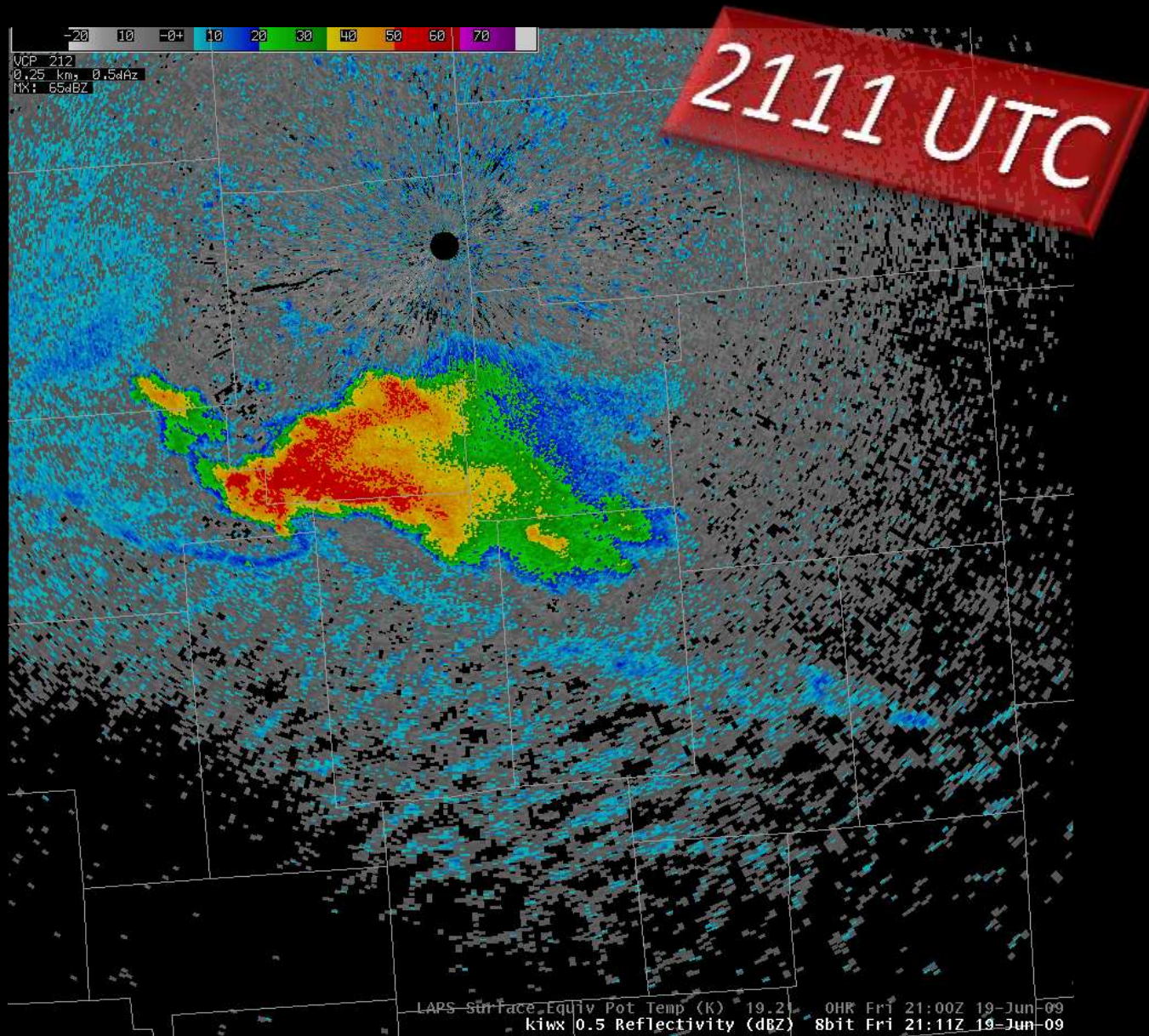




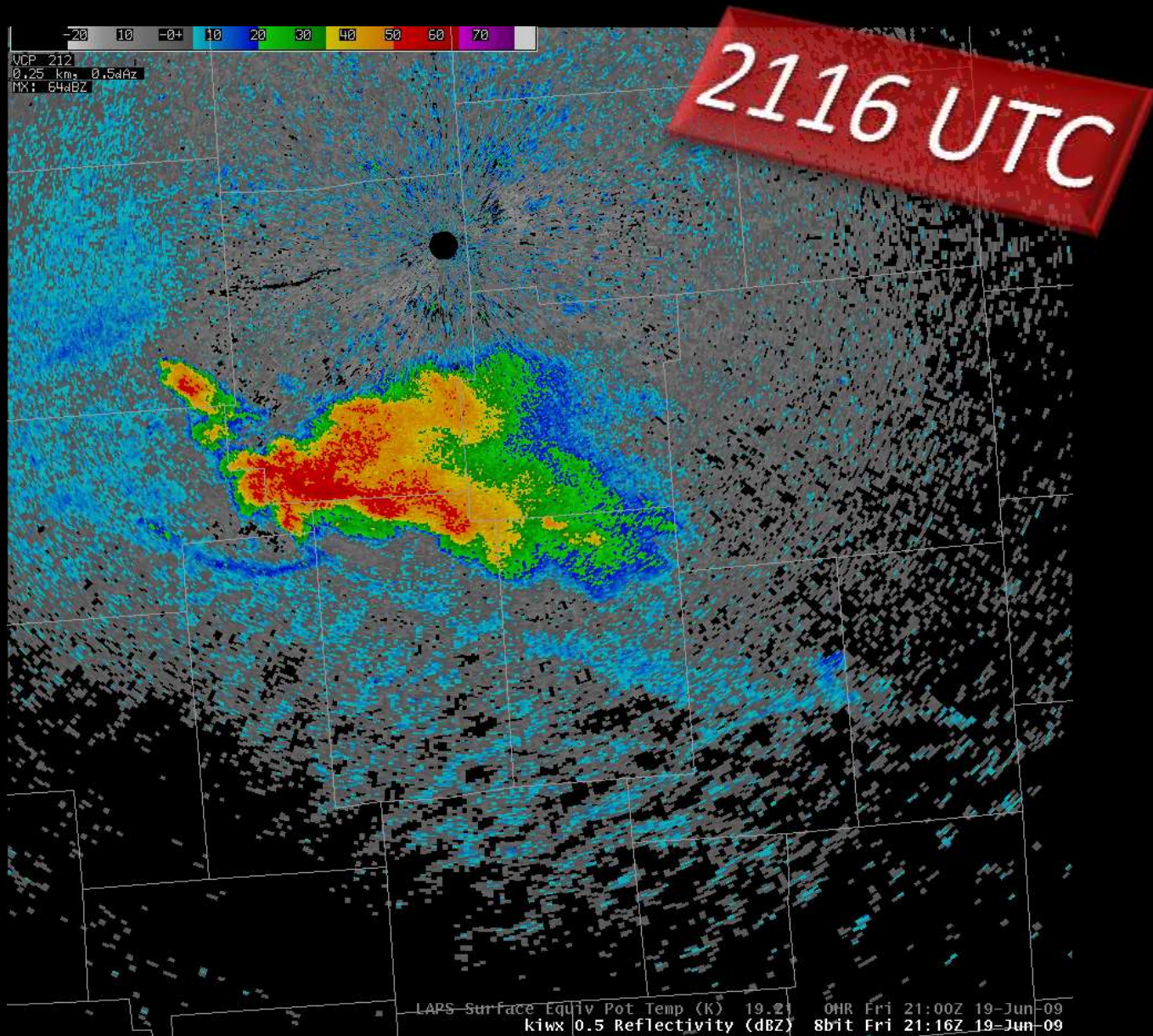
Storm Crosses Boundary

- So...here we go...the big show... This supercell has to produce a tornado once it moves to the immediate north side of the boundary, right??
- Don't You Think?
- Wrong!!
- Why not?

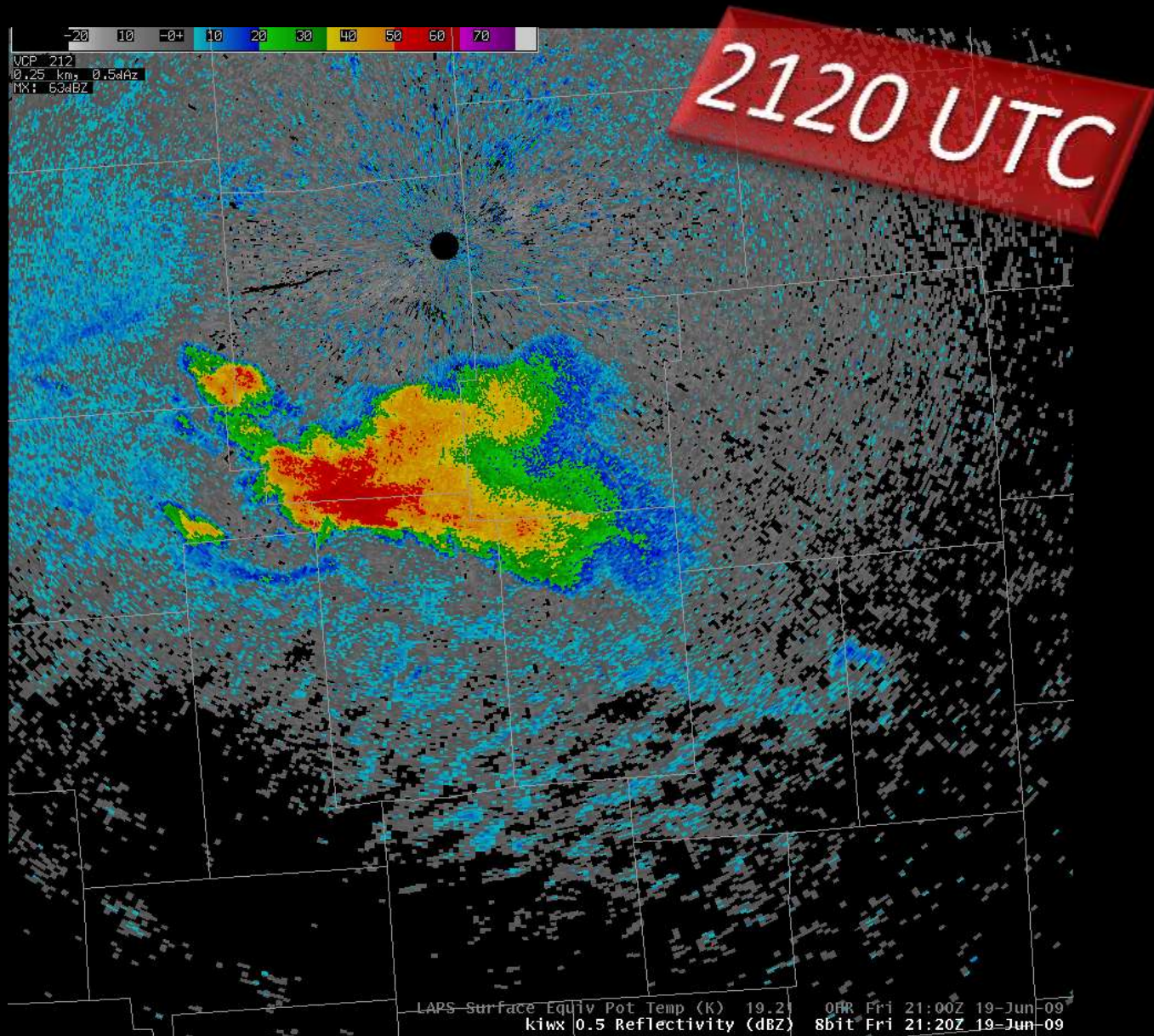
0.5 Degree Reflectivity



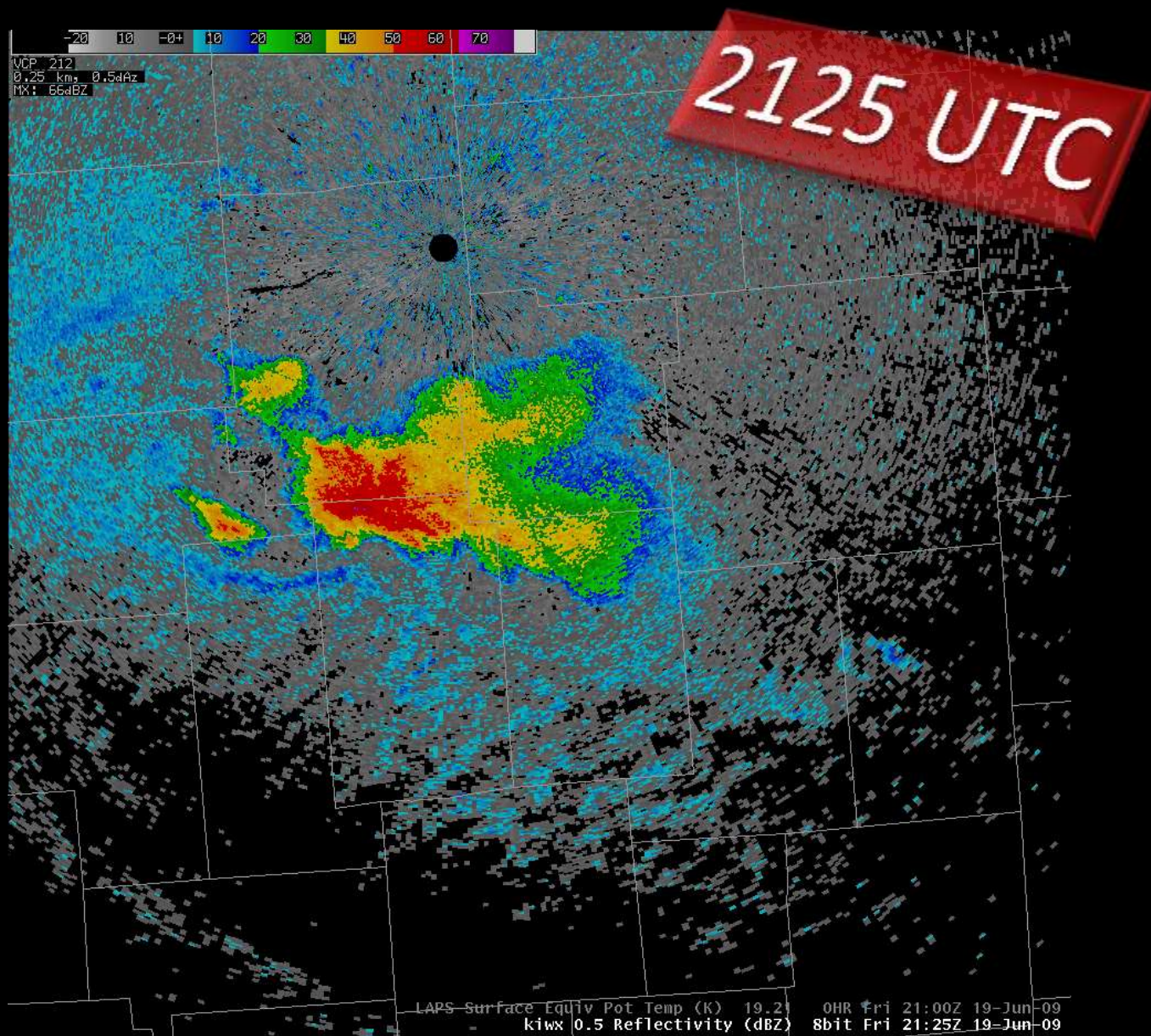
0.5 Degree Reflectivity



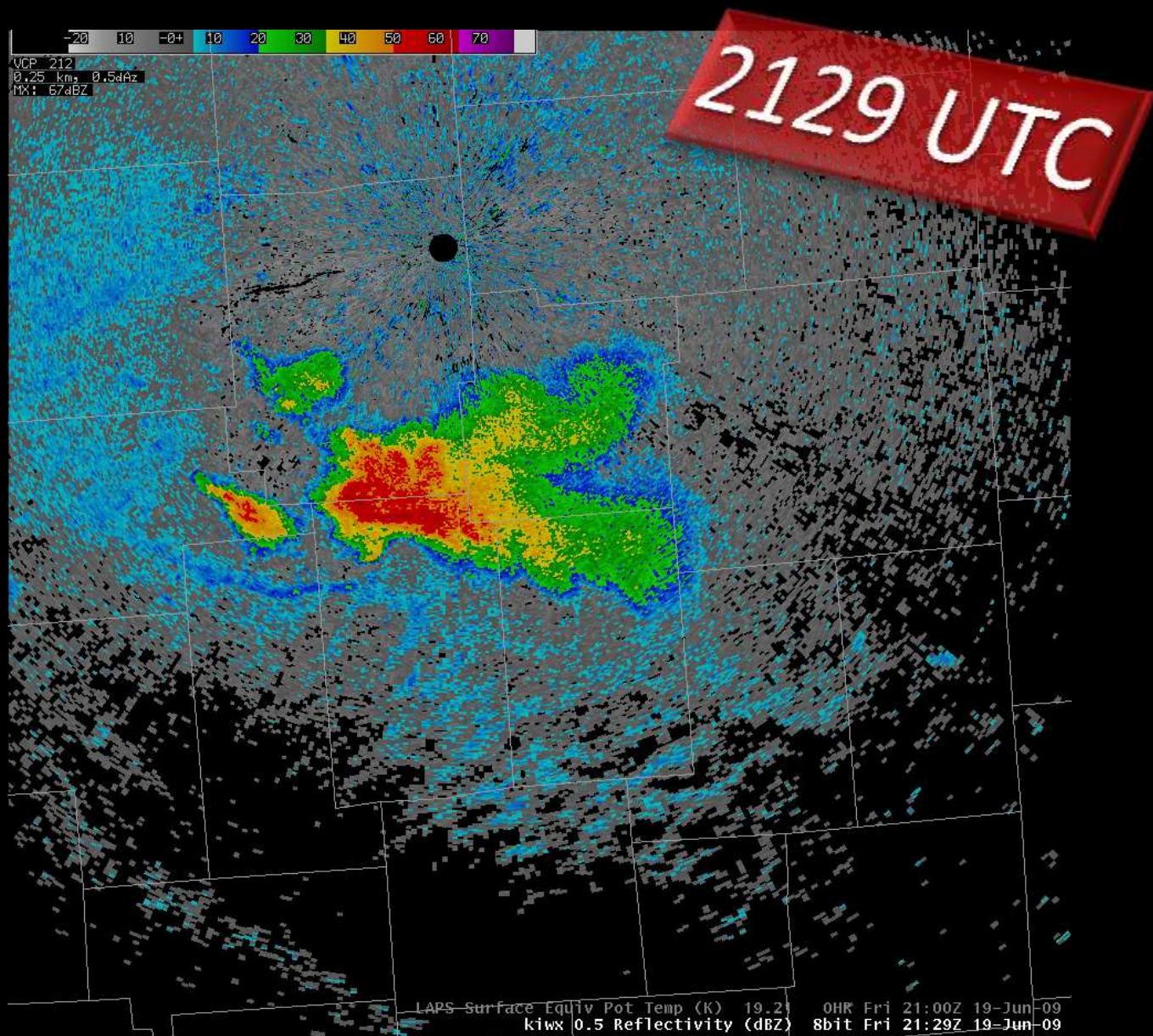
0.5 Degree Reflectivity



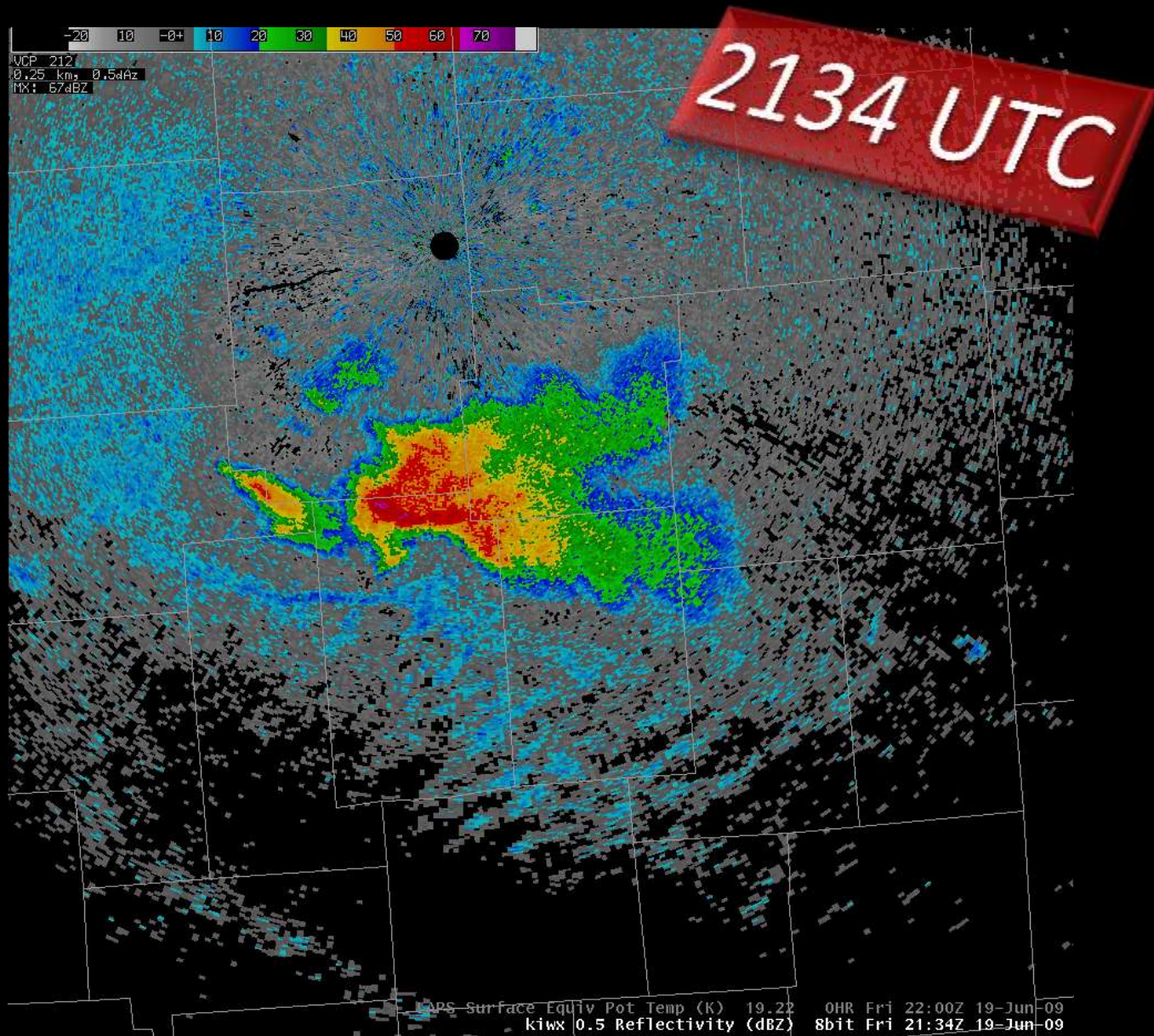
0.5 Degree Reflectivity



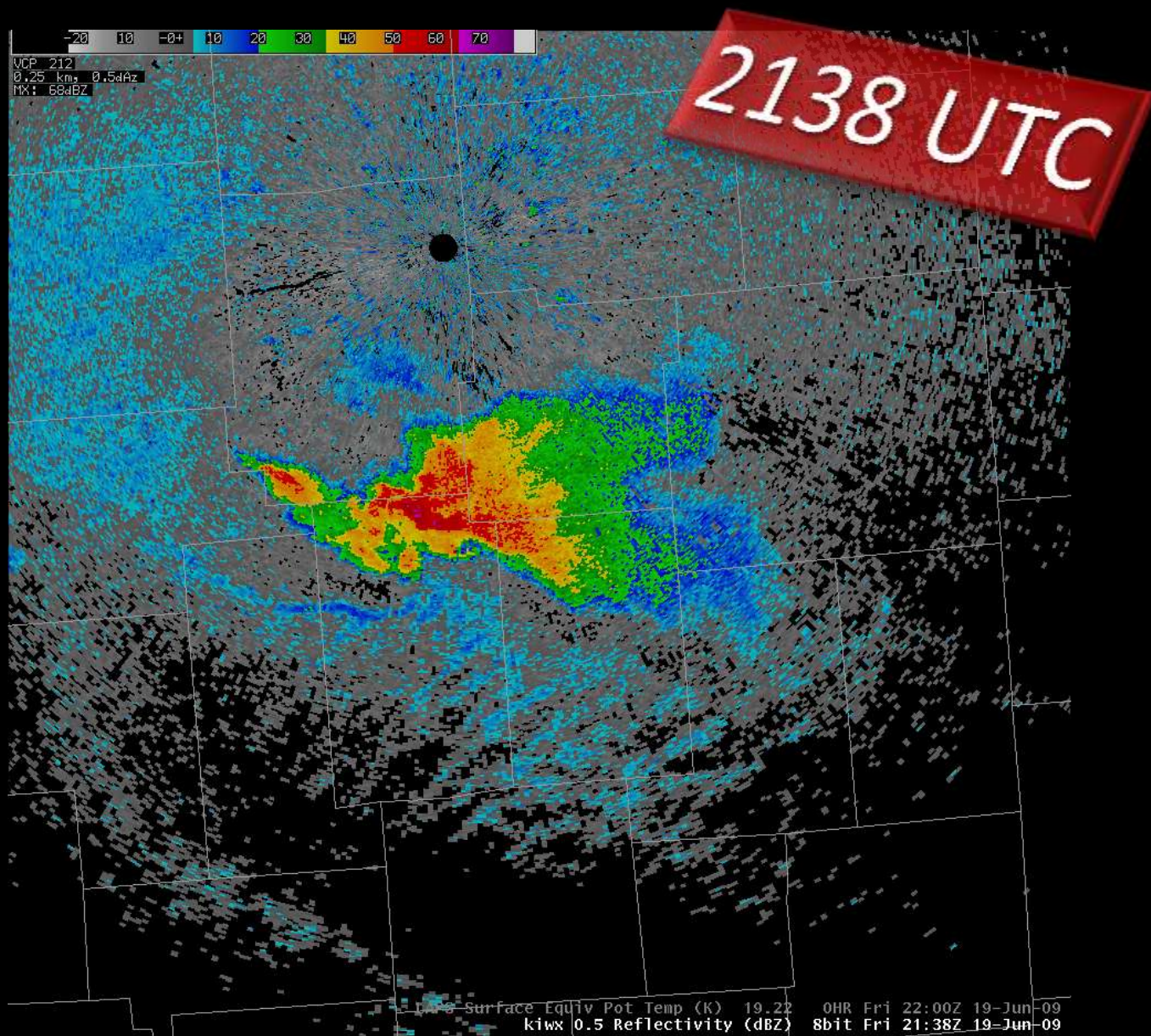
0.5 Degree Reflectivity



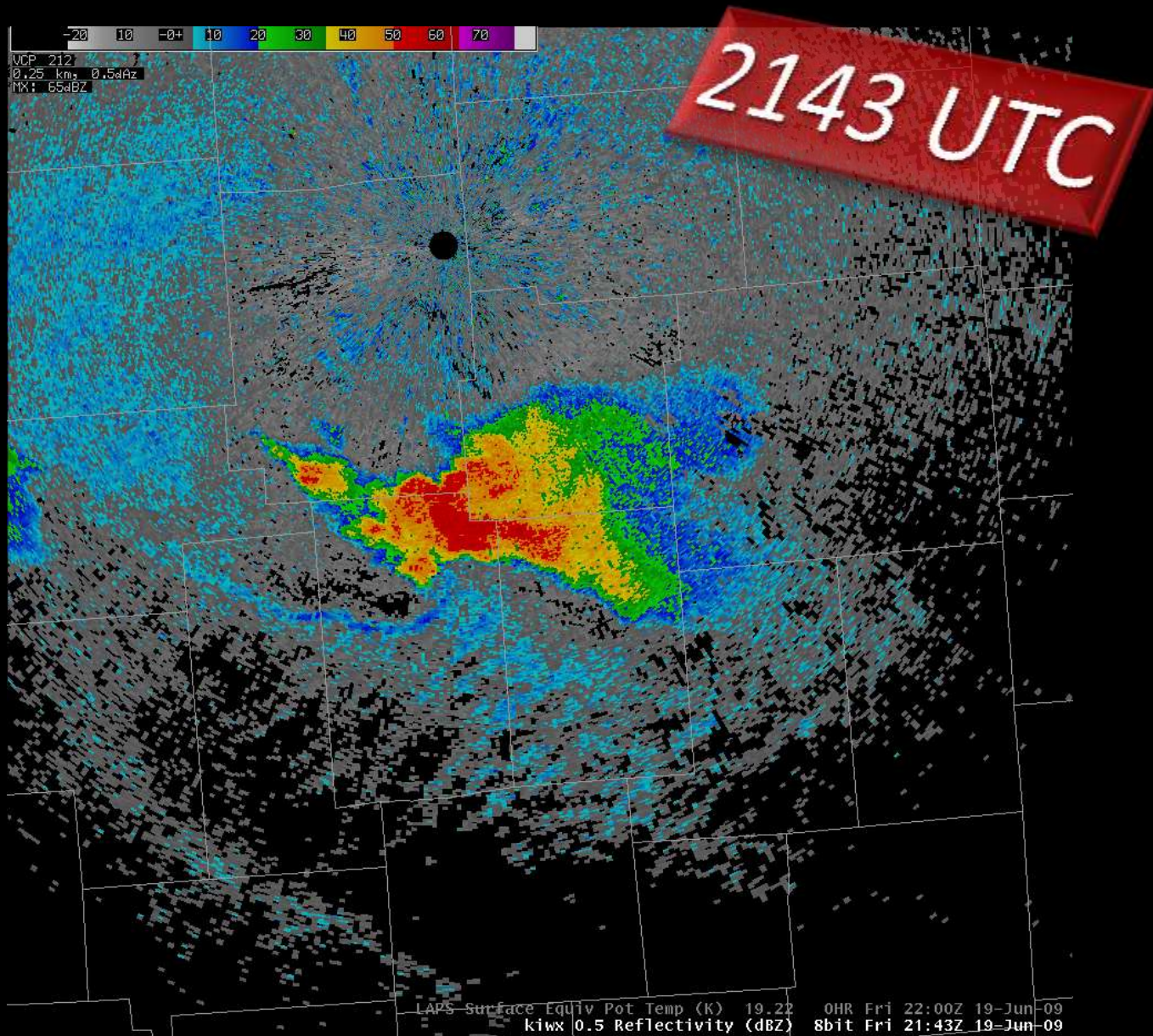
0.5 Degree Reflectivity



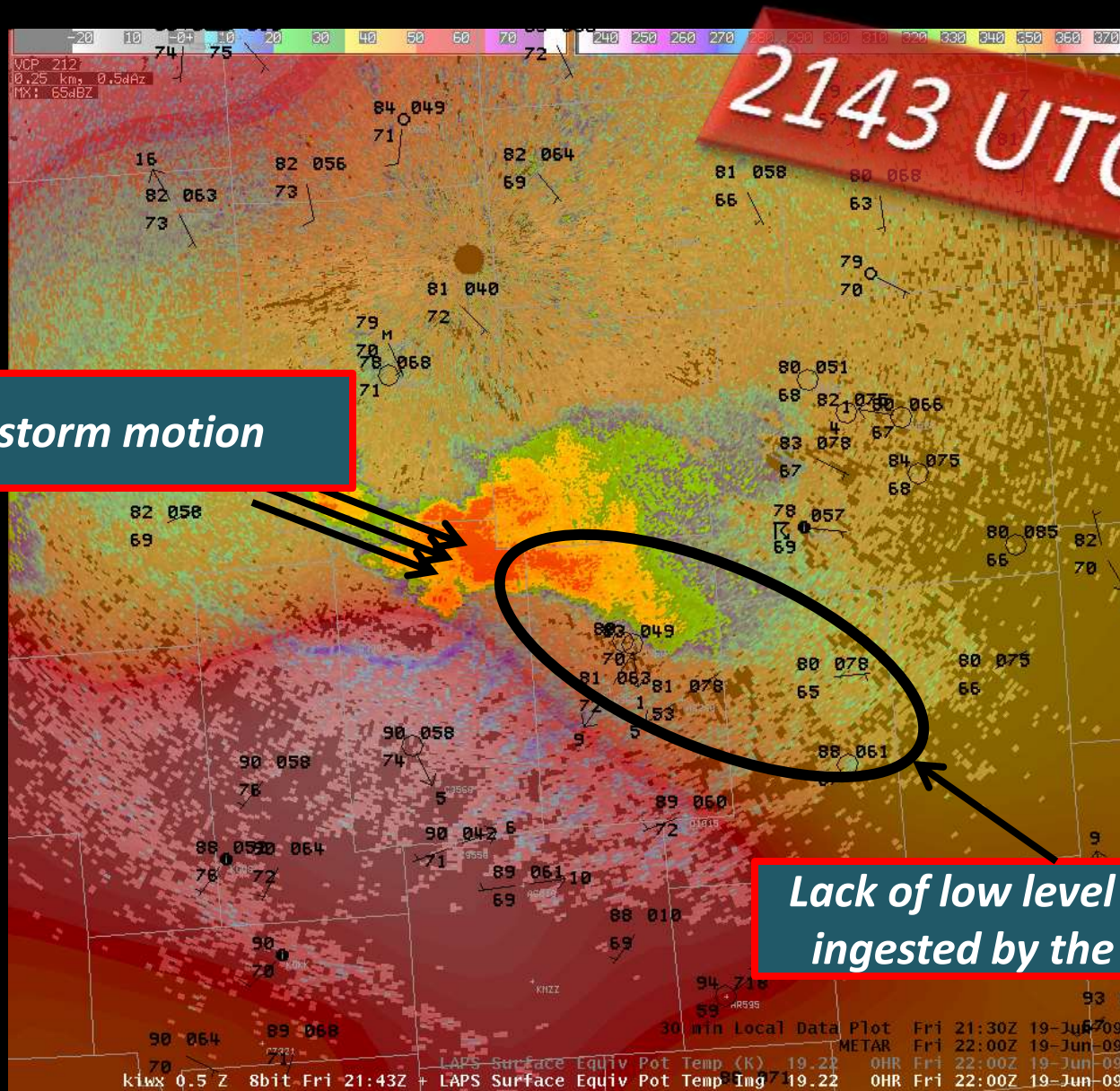
0.5 Degree Reflectivity



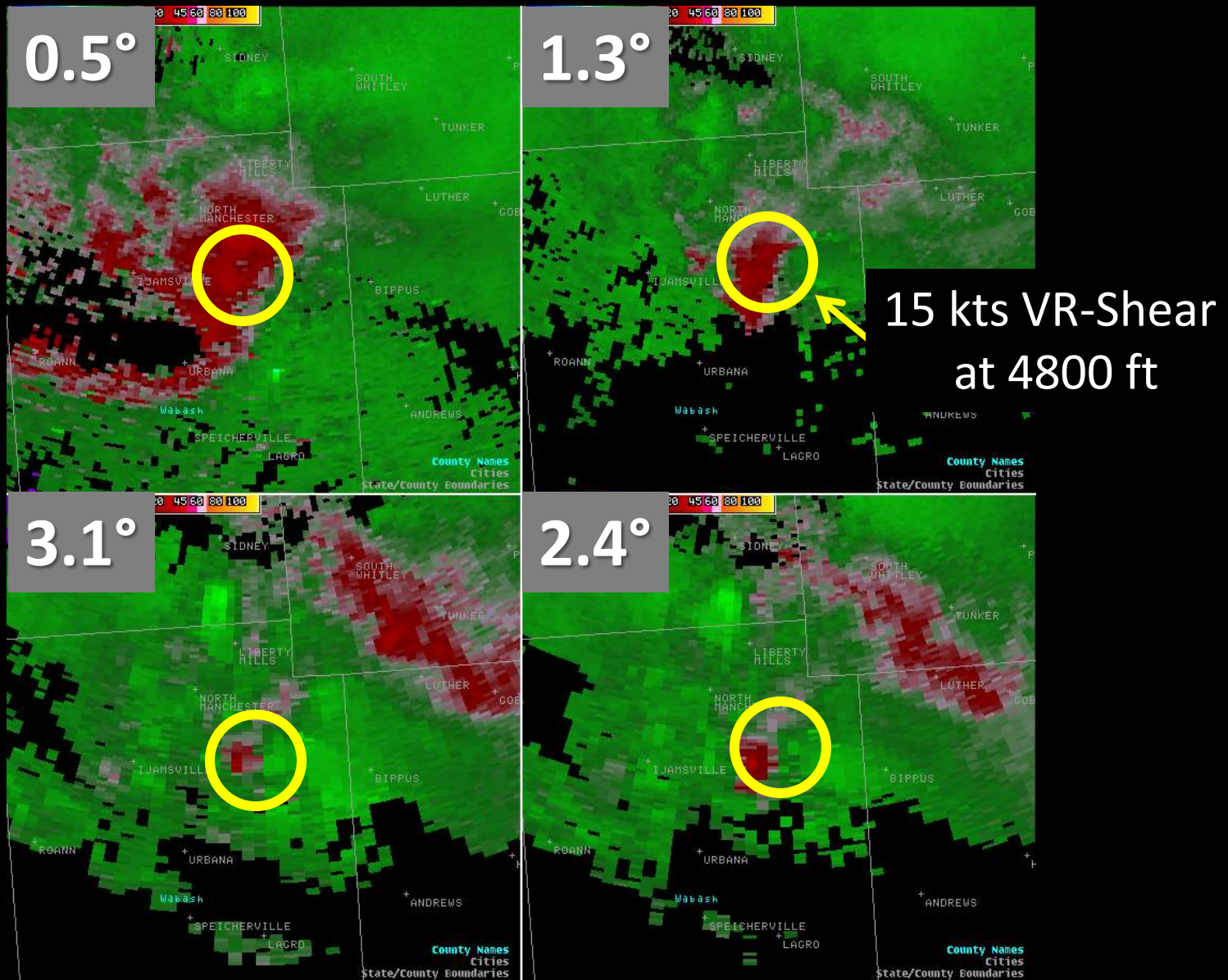
0.5 Degree Reflectivity

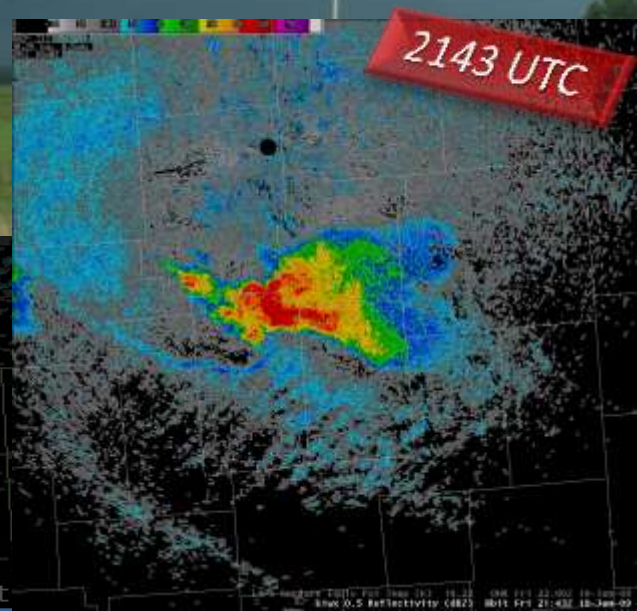
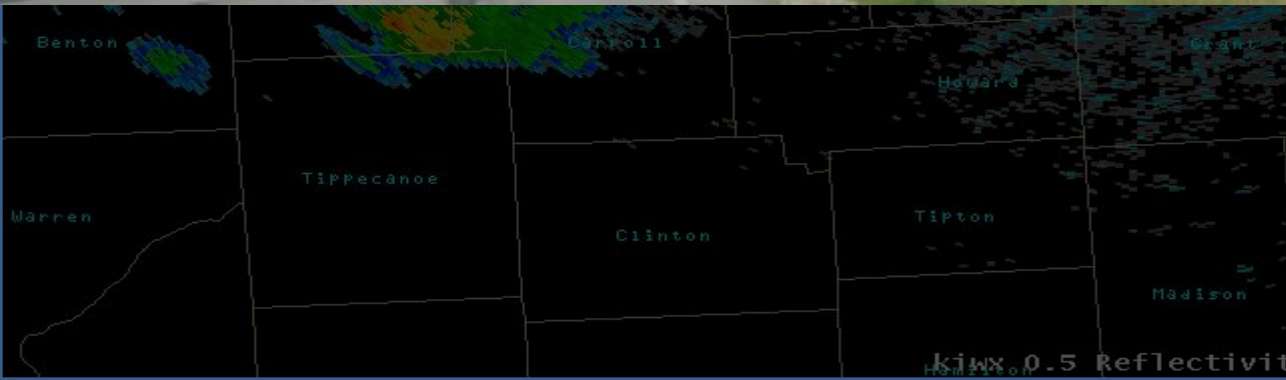
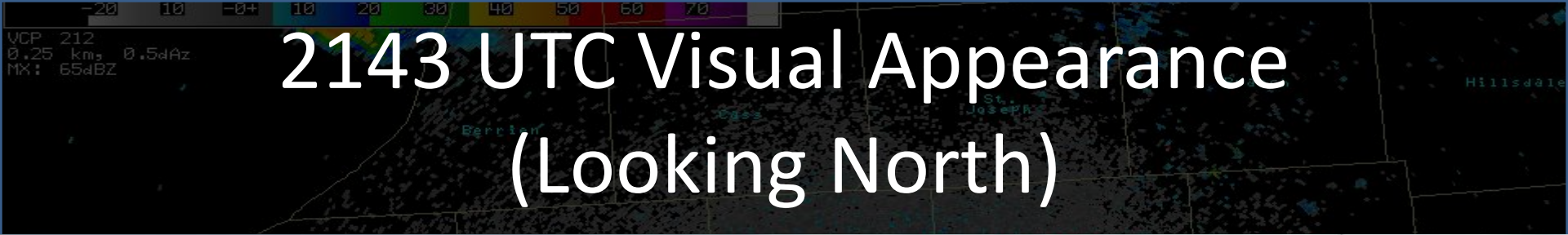


LAPS Surface Theta E & Observations

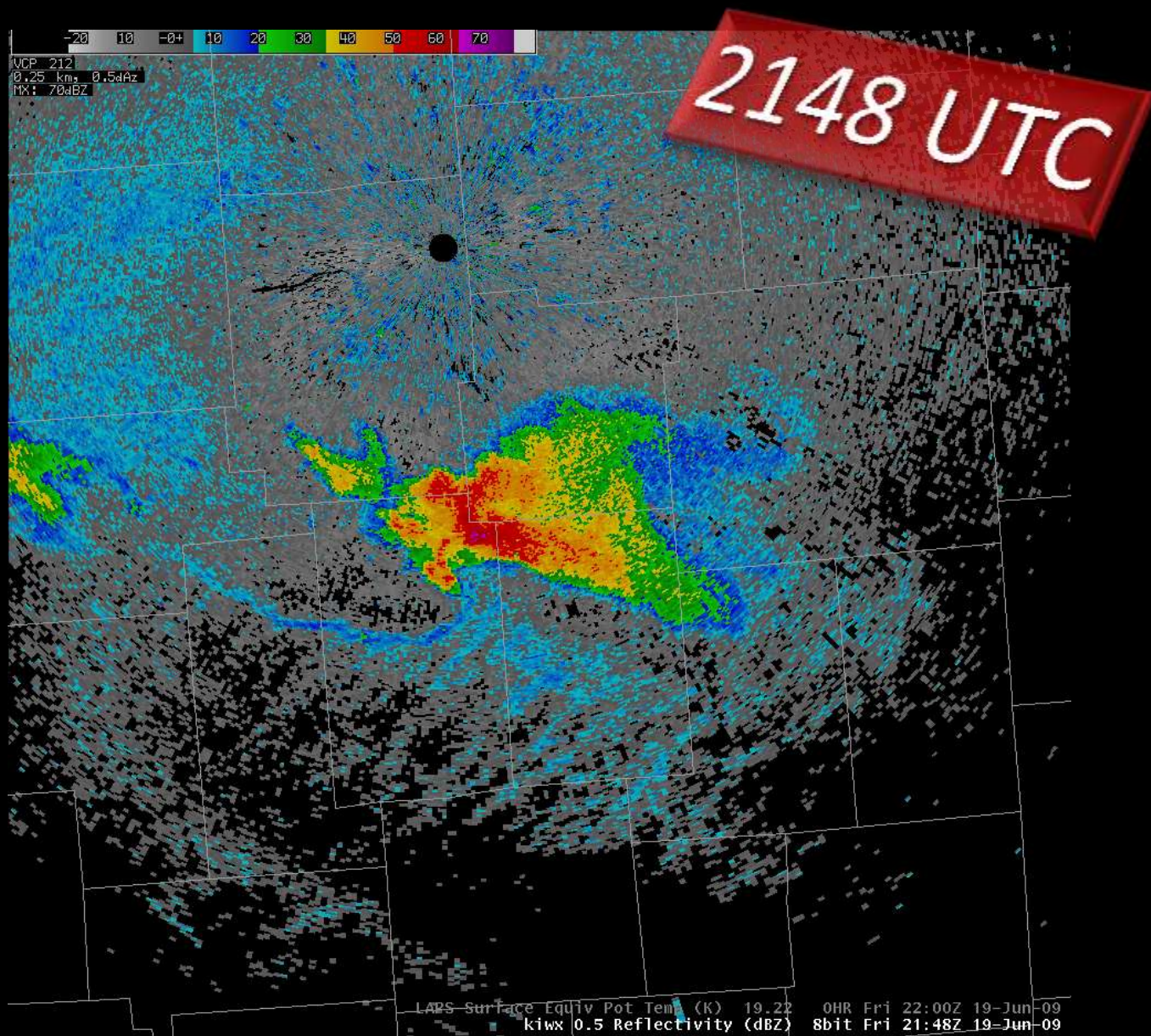


2143 UTC Storm Relative Motion

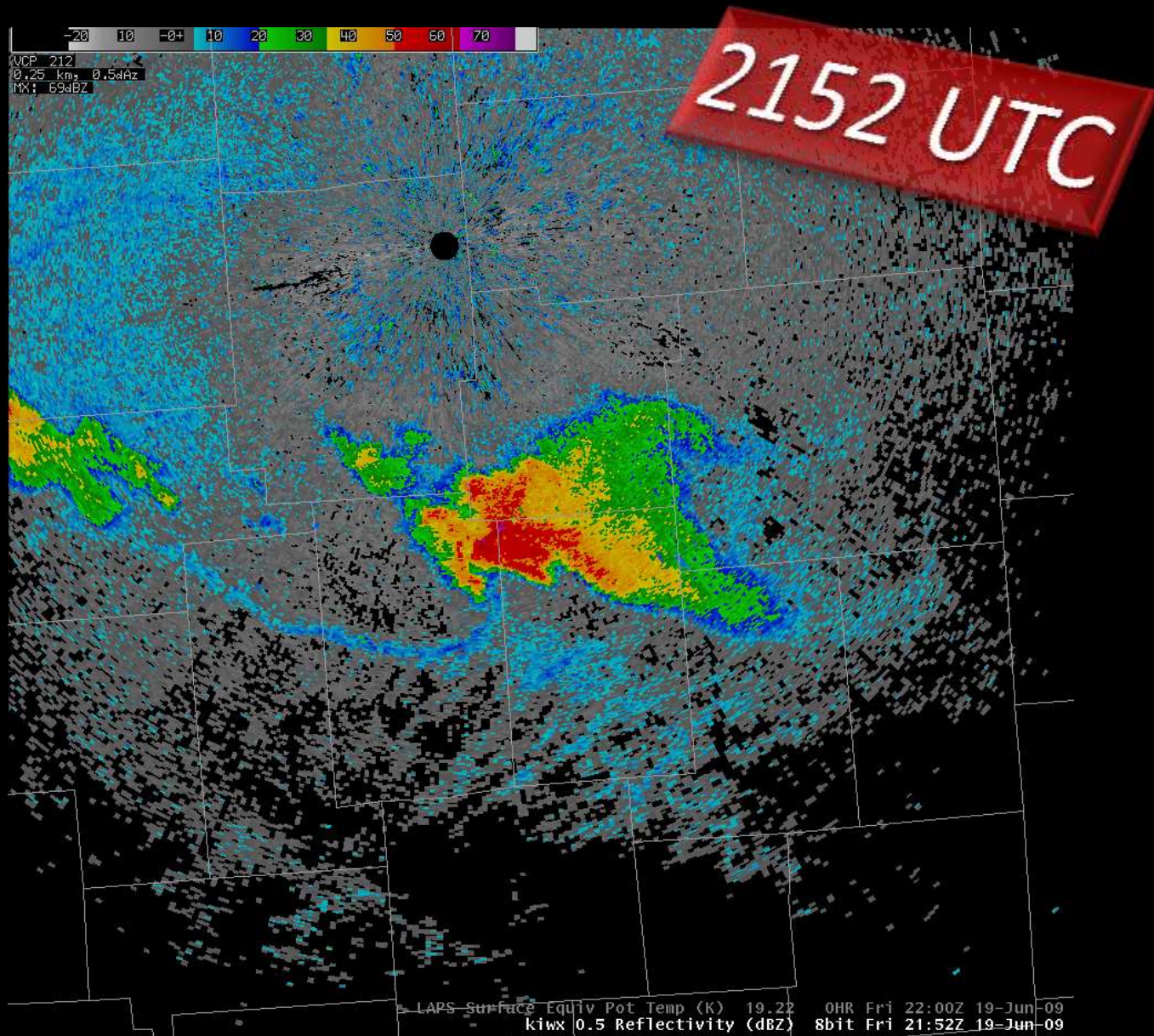




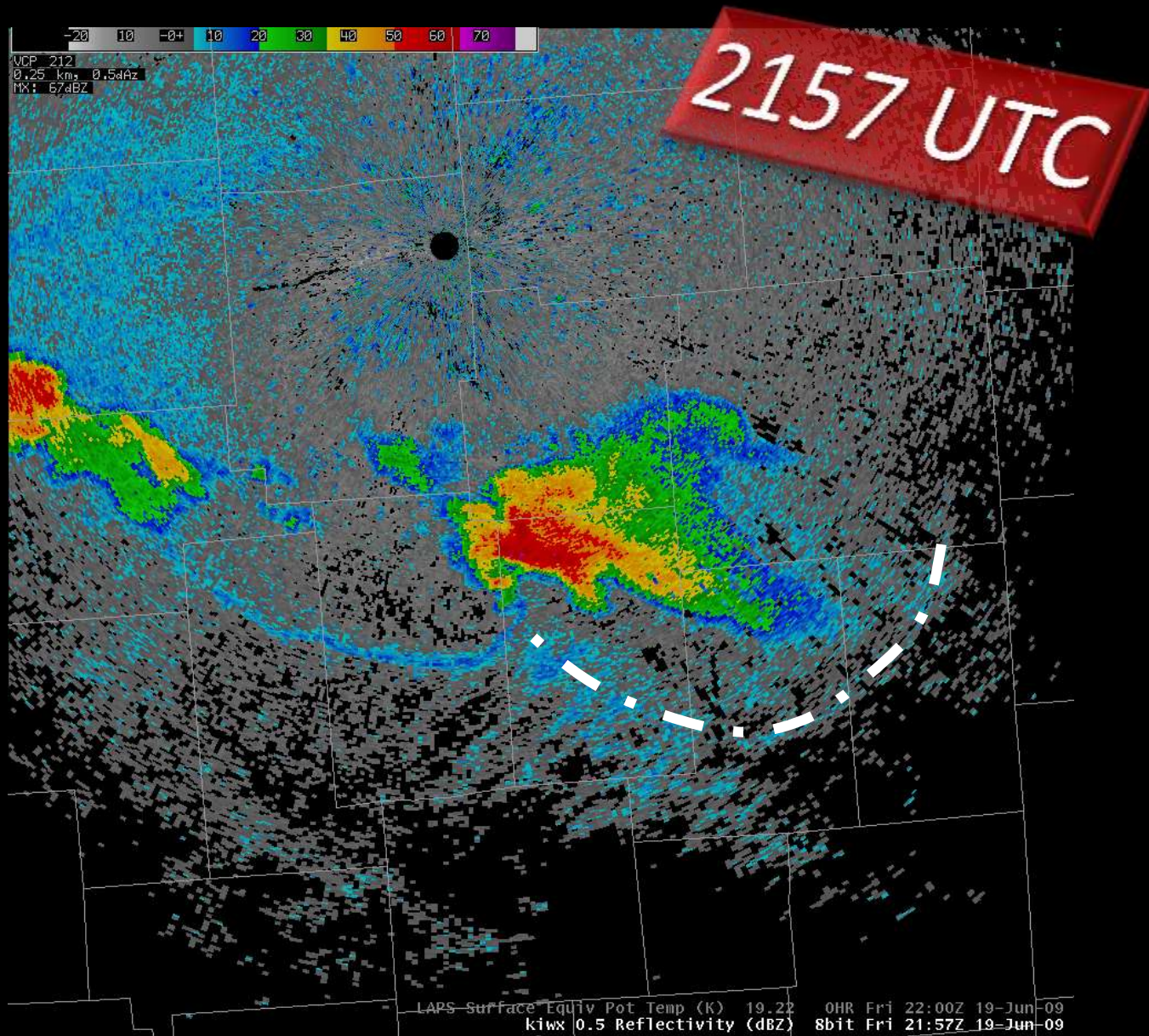
0.5 Degree Reflectivity



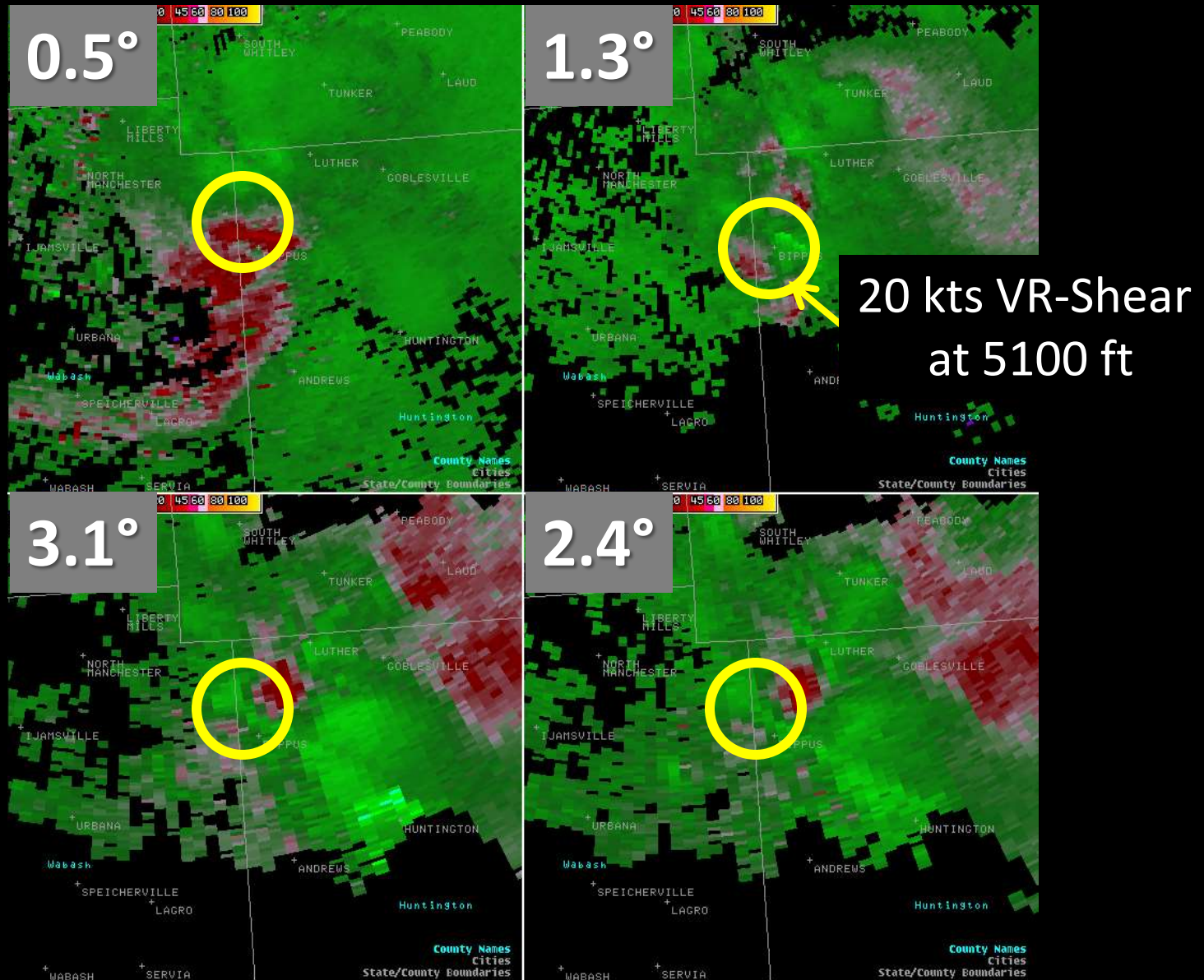
0.5 Degree Reflectivity



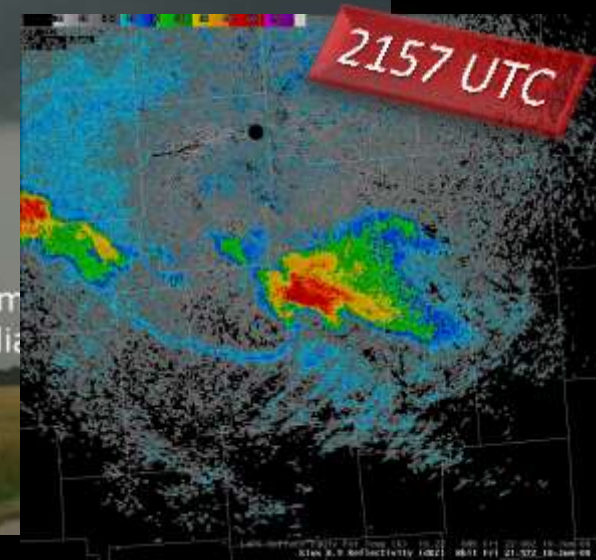
0.5 Degree Reflectivity



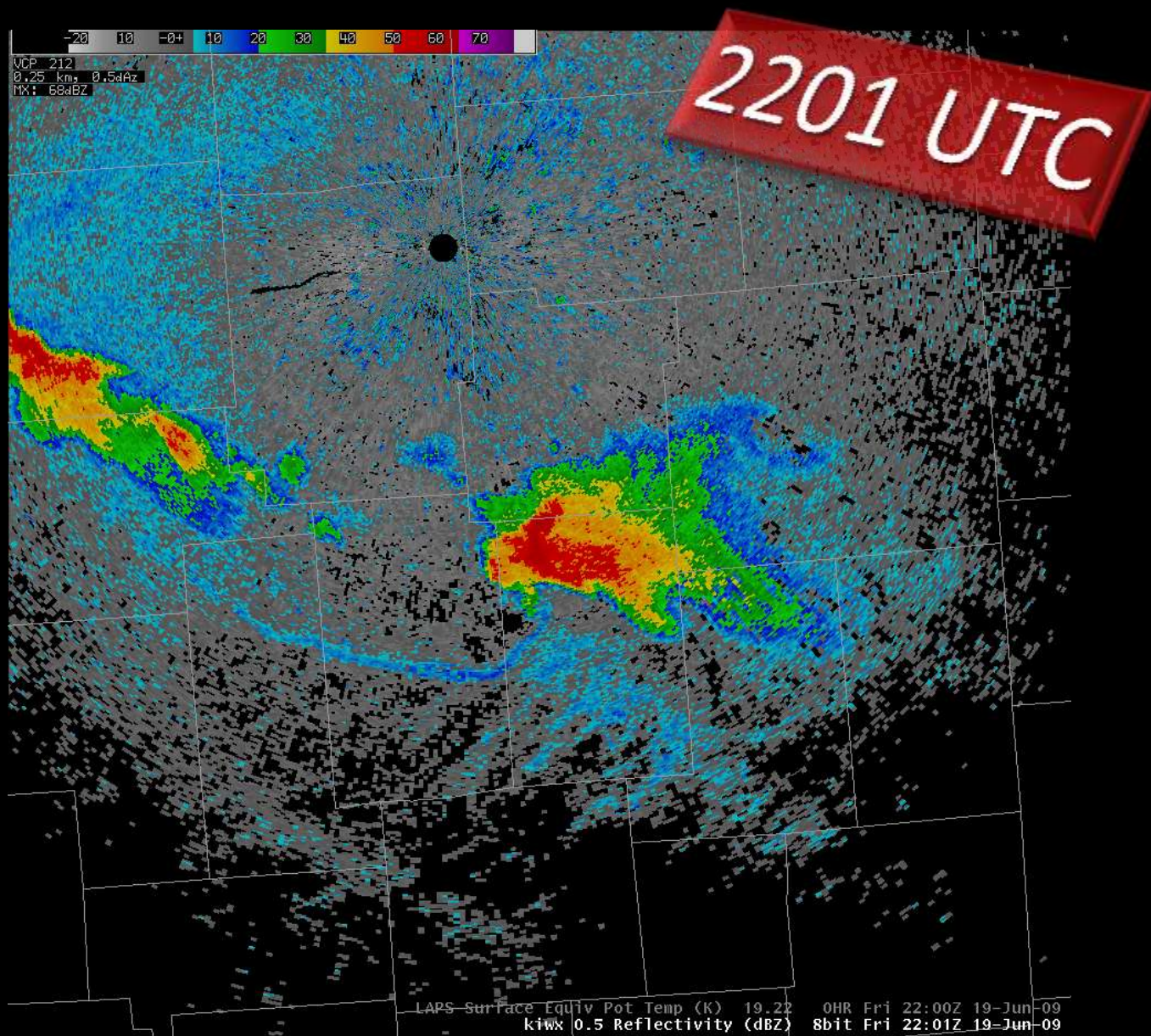
2157 UTC Storm Relative Motion



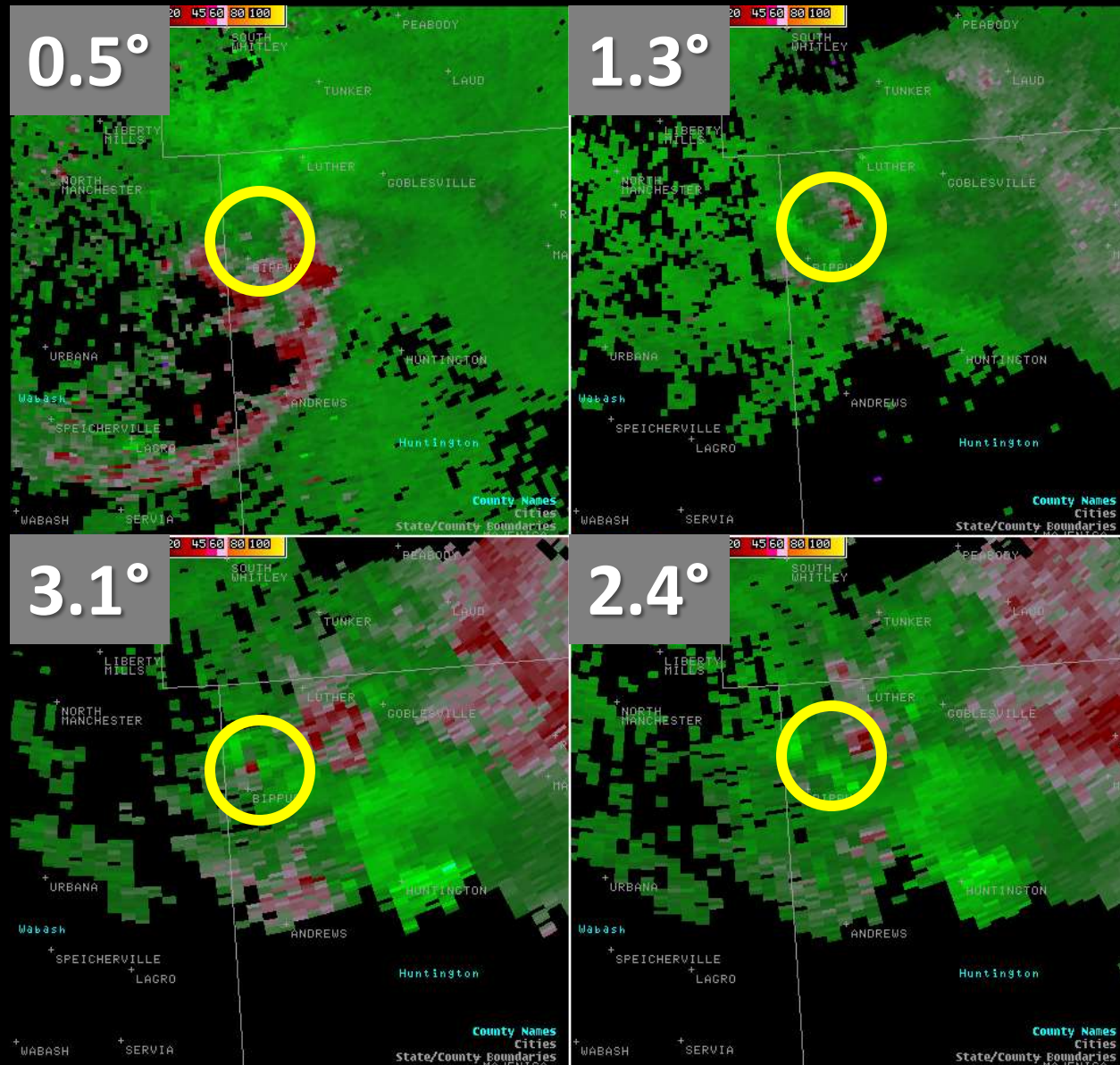
2157 UTC Visual Appearance (Looking East Northeast)



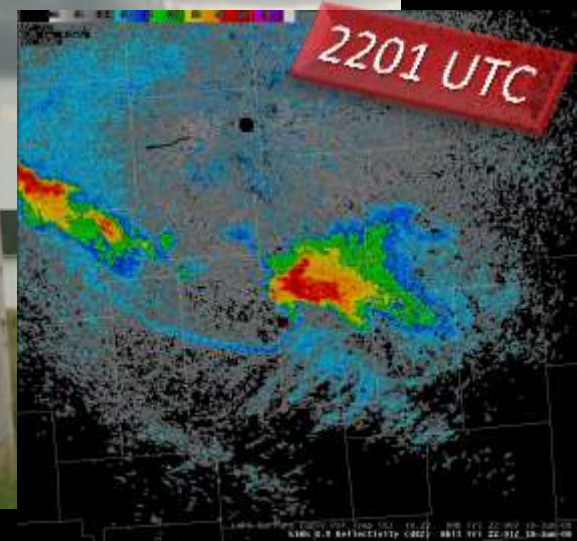
0.5 Degree Reflectivity



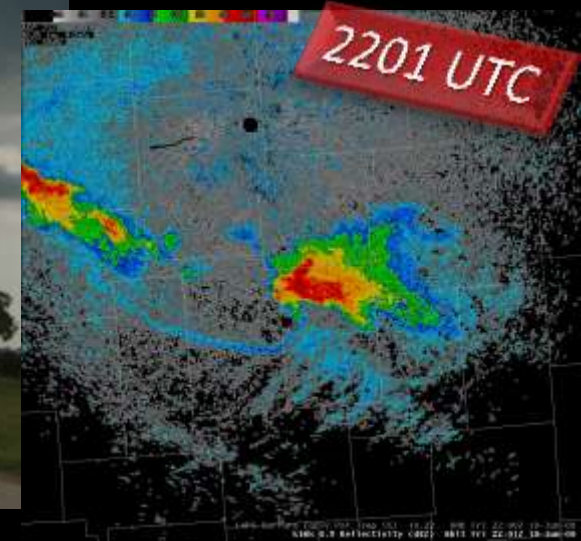
2201 UTC Storm Relative Motion



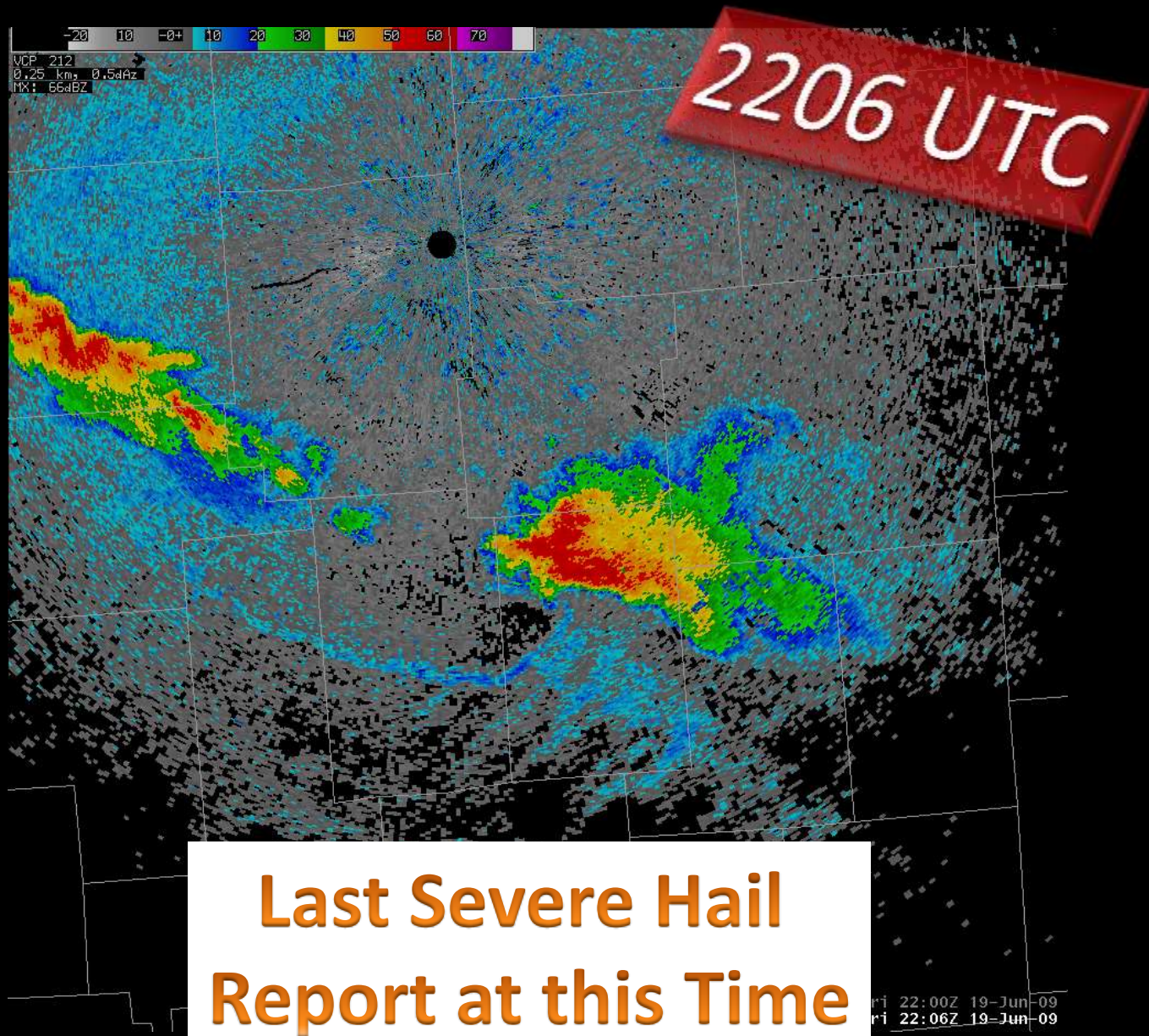
2201 UTC Visual Appearance (Looking East Northeast)



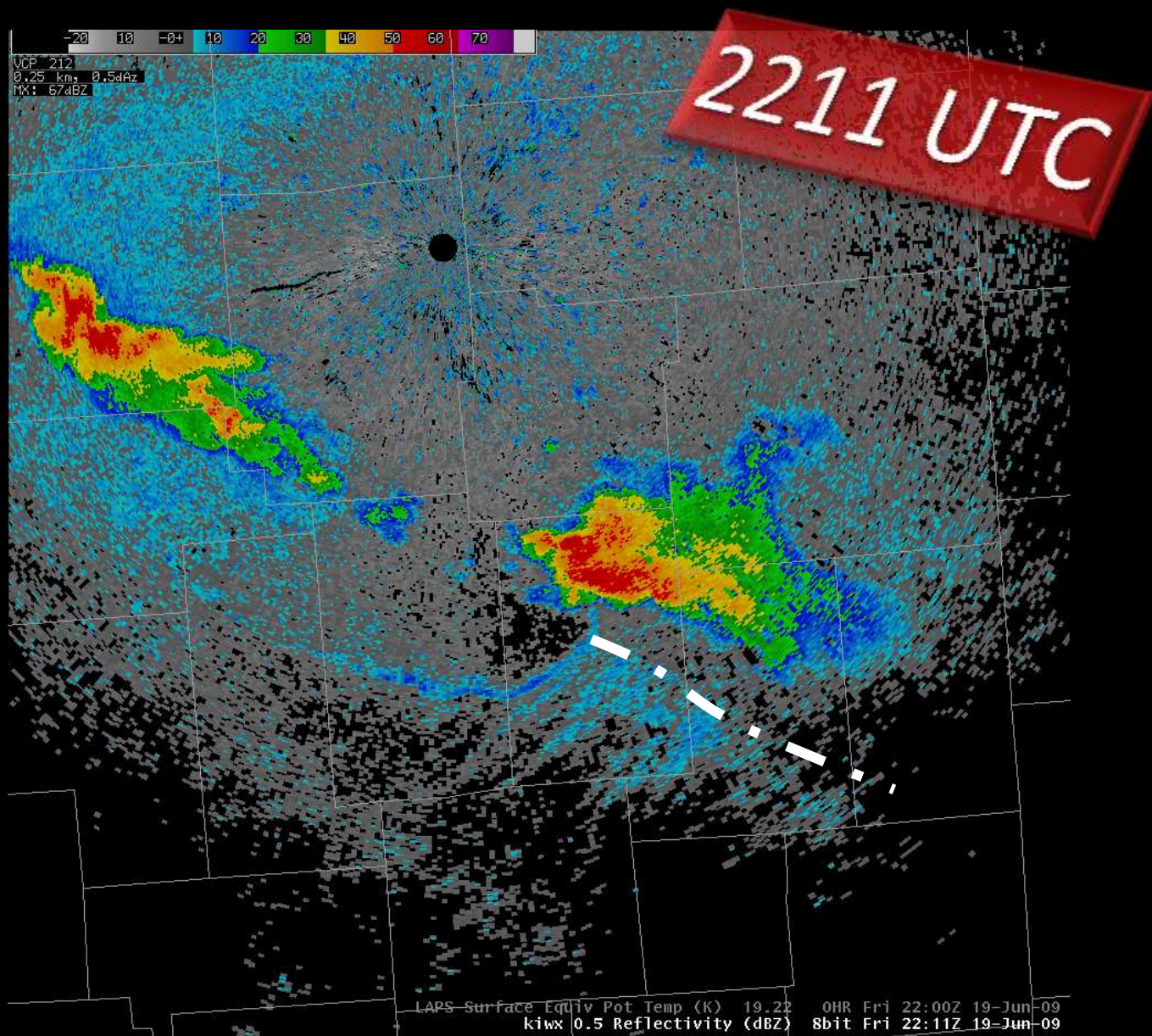
2201 UTC Visual Appearance (Looking East Northeast)



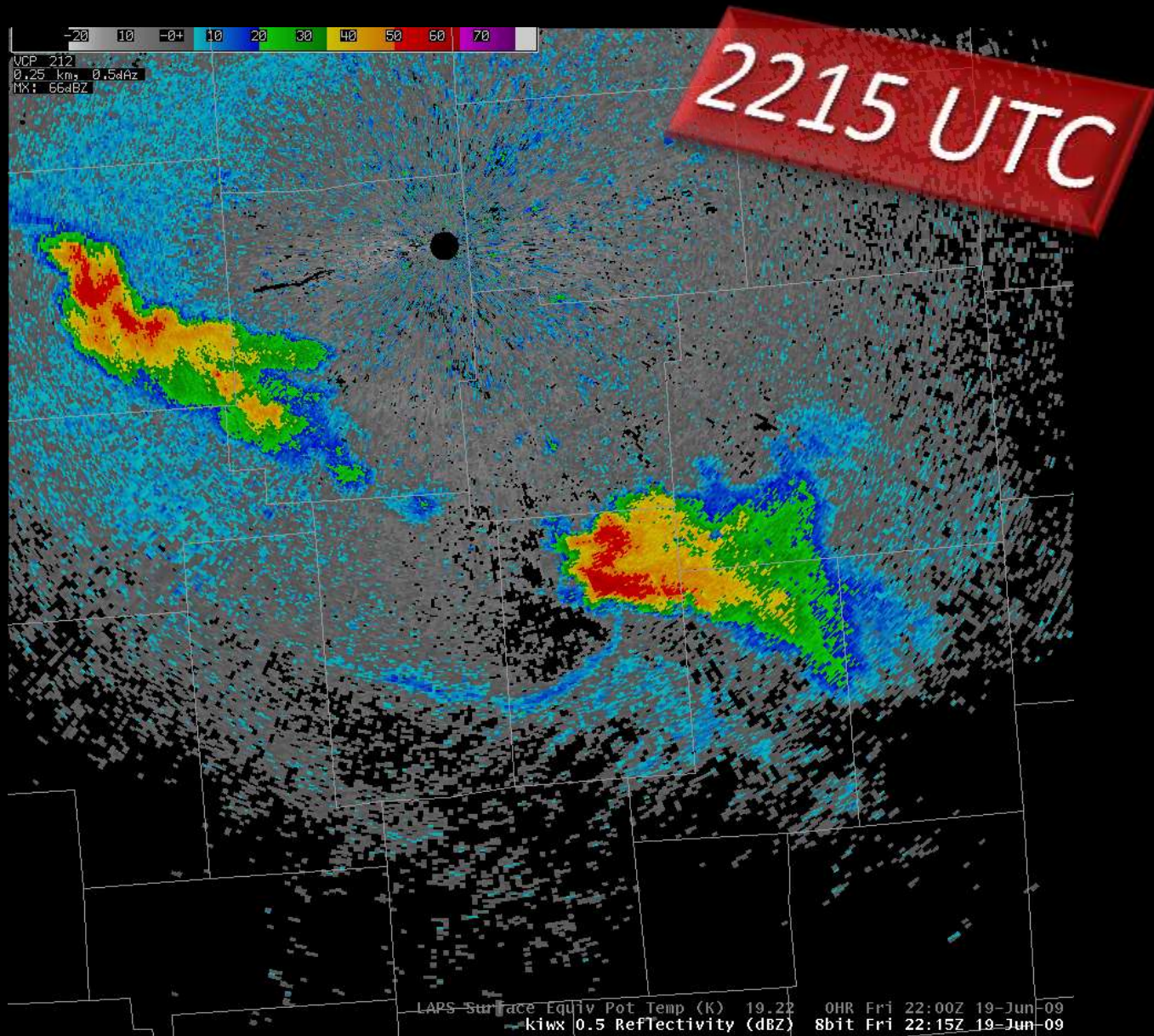
0.5 Degree Reflectivity



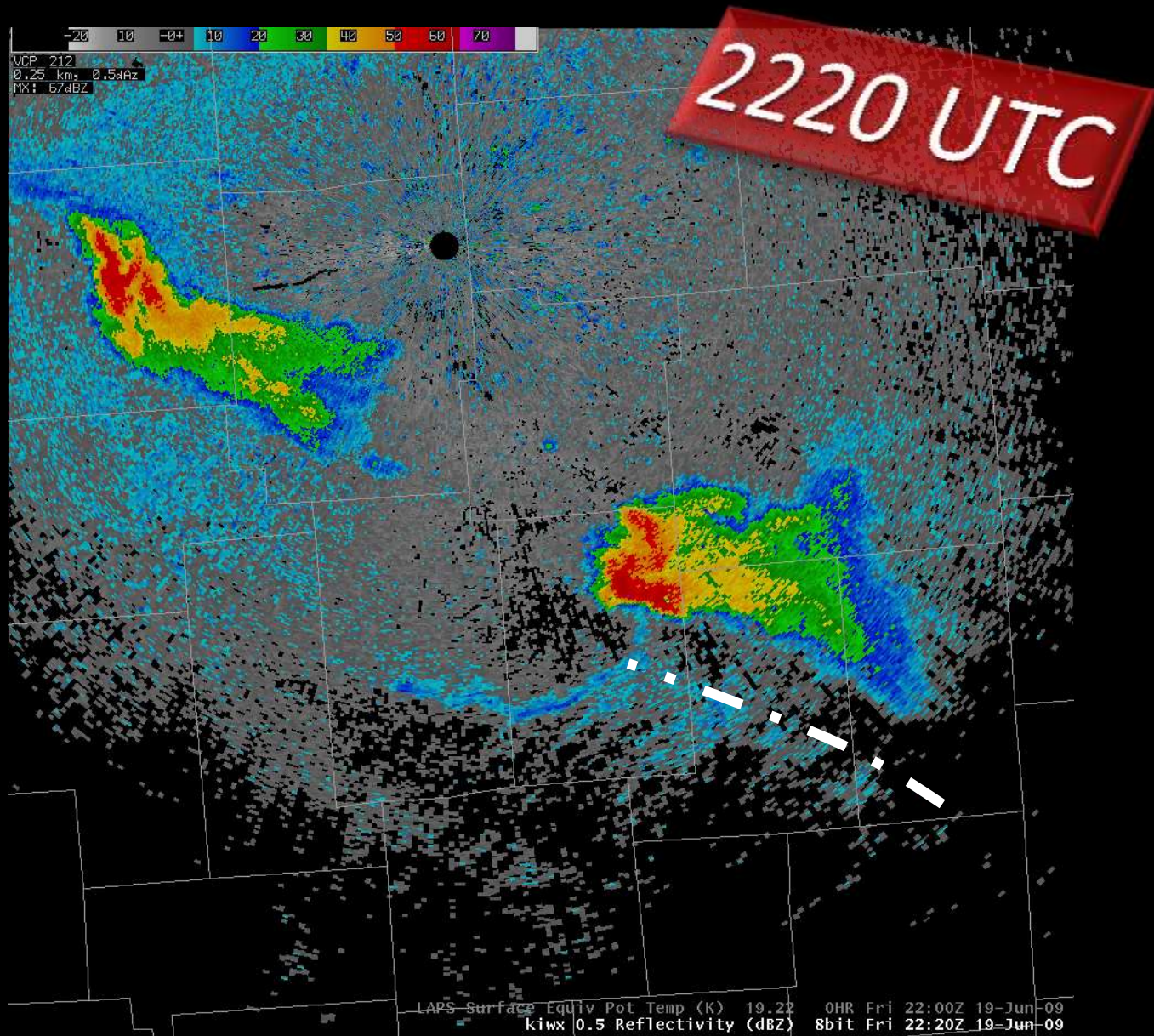
0.5 Degree Reflectivity



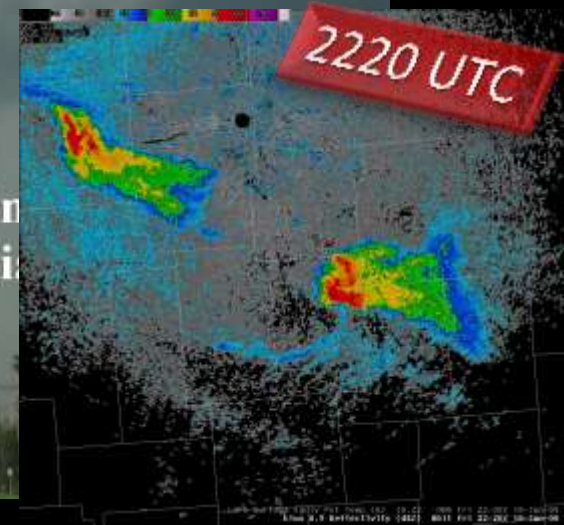
0.5 Degree Reflectivity



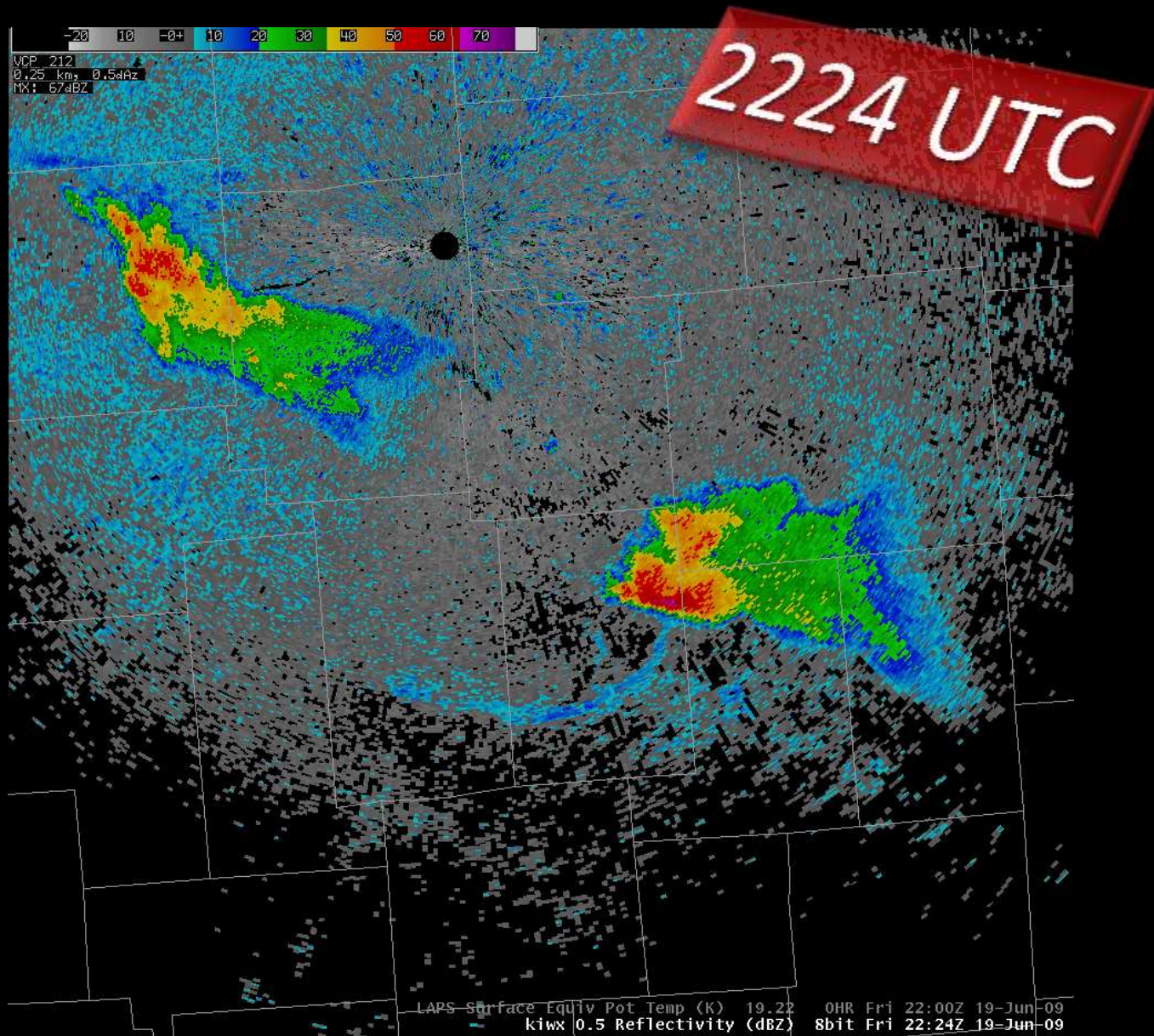
0.5 Degree Reflectivity



2220 UTC Visual Appearance



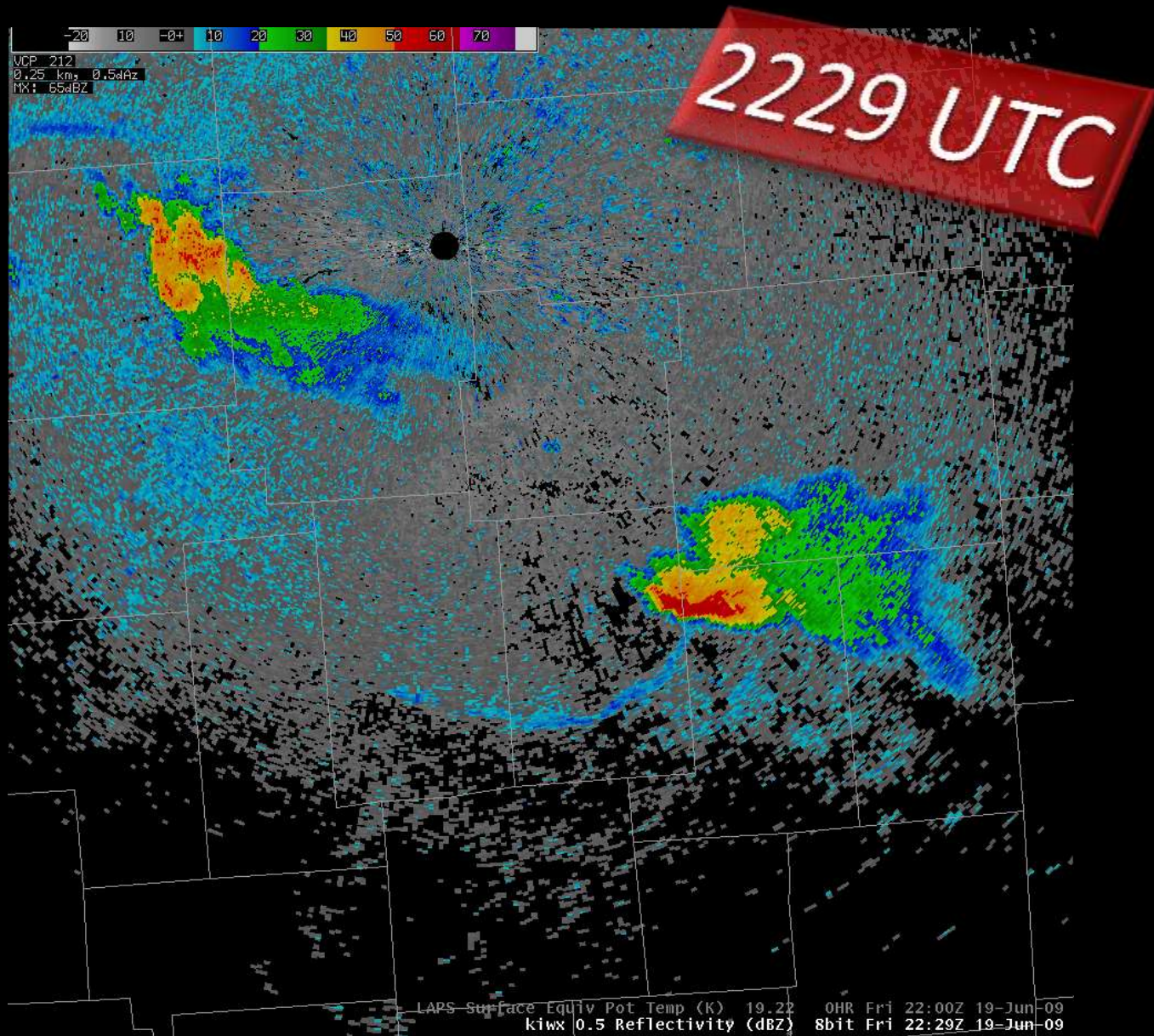
0.5 Degree Reflectivity



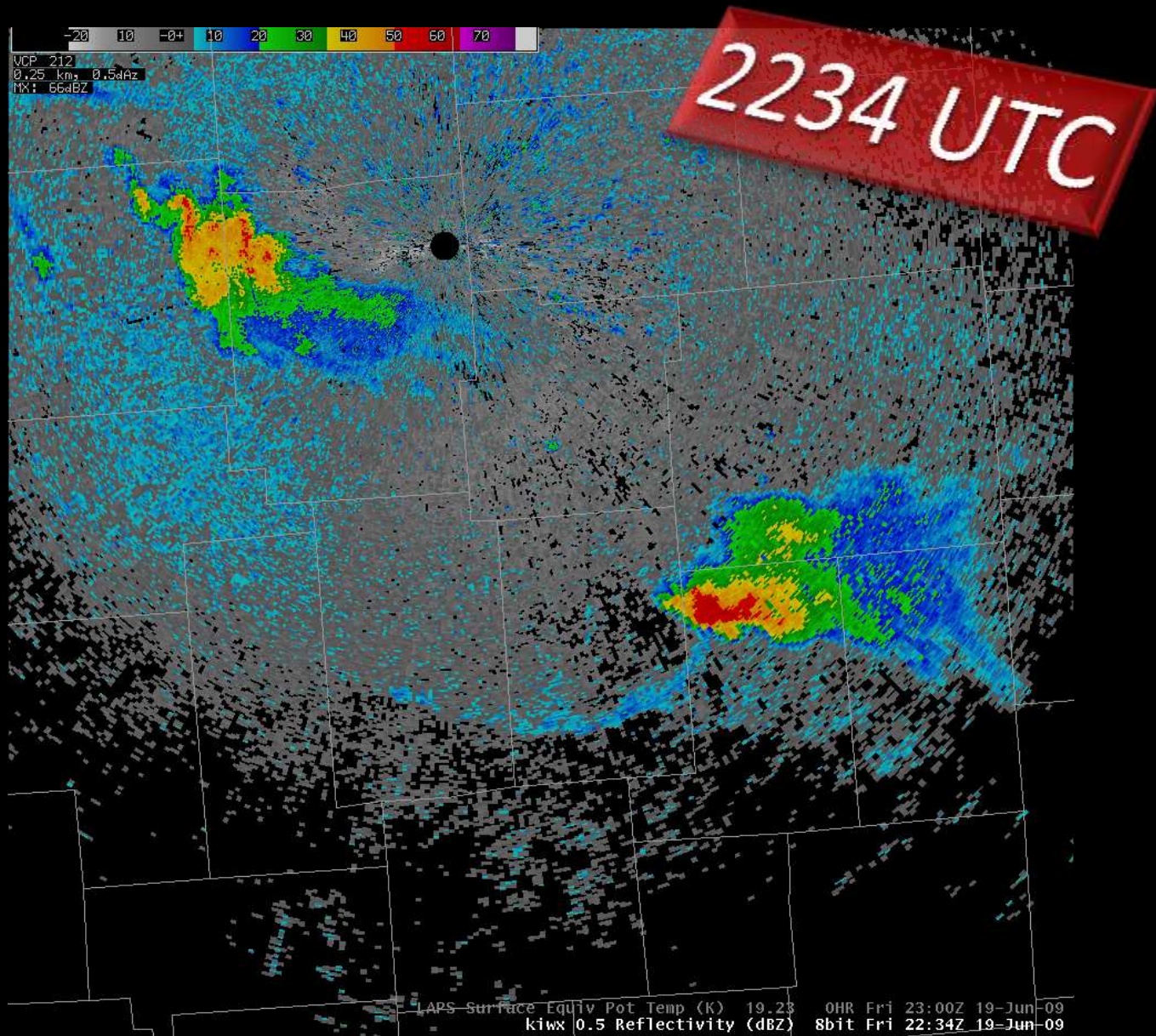
2224 UTC Visual Appearance



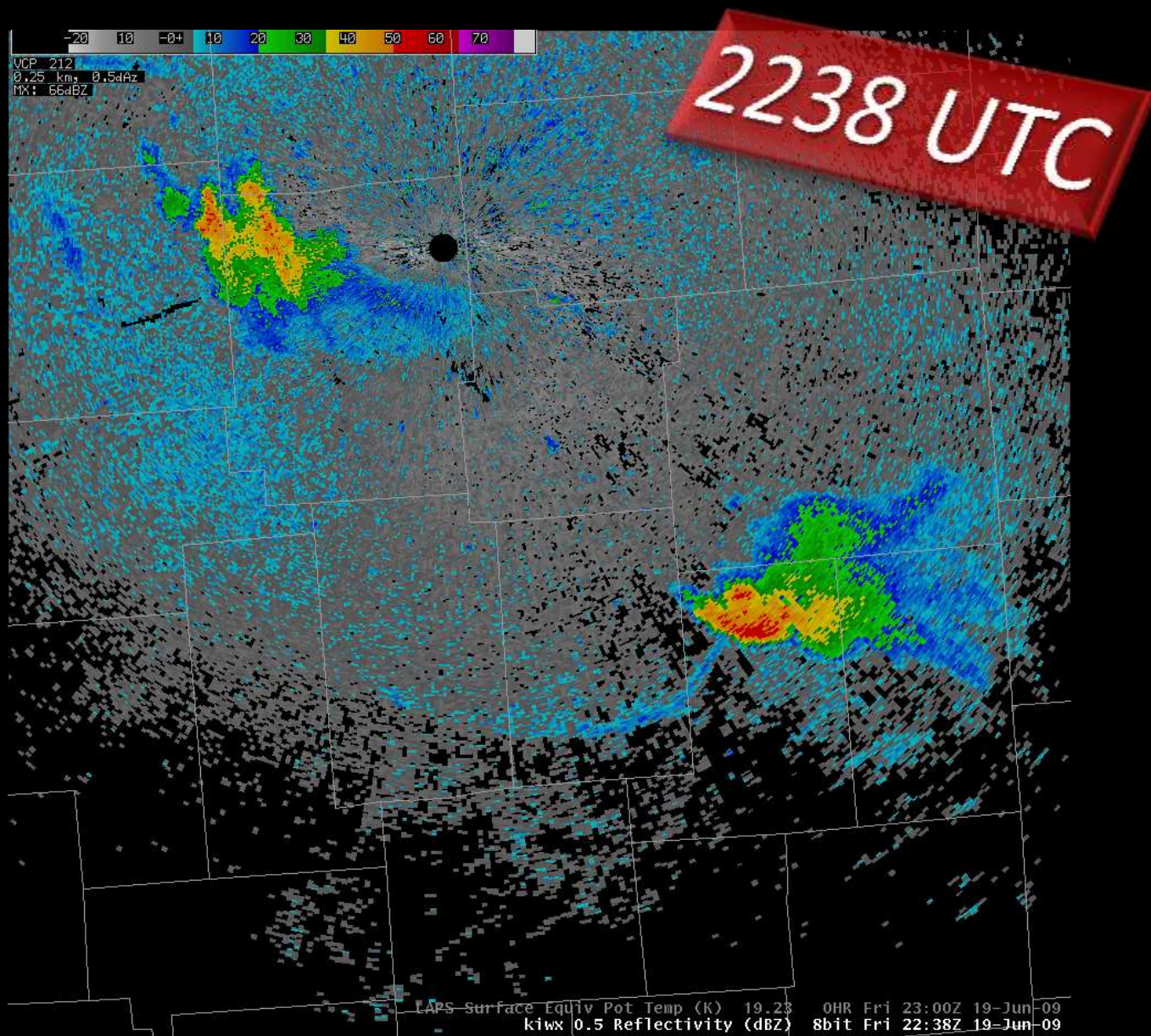
0.5 Degree Reflectivity



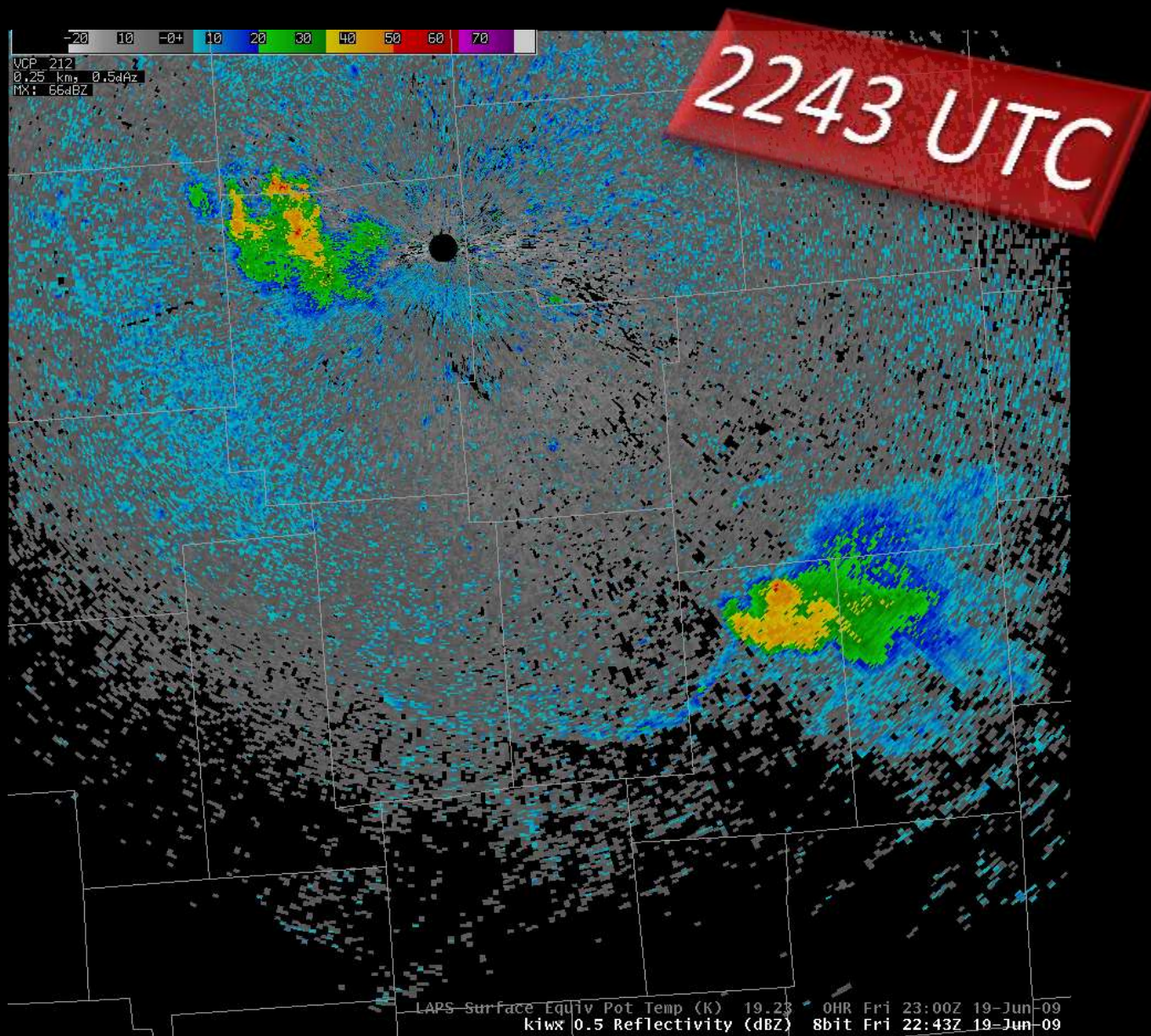
0.5 Degree Reflectivity



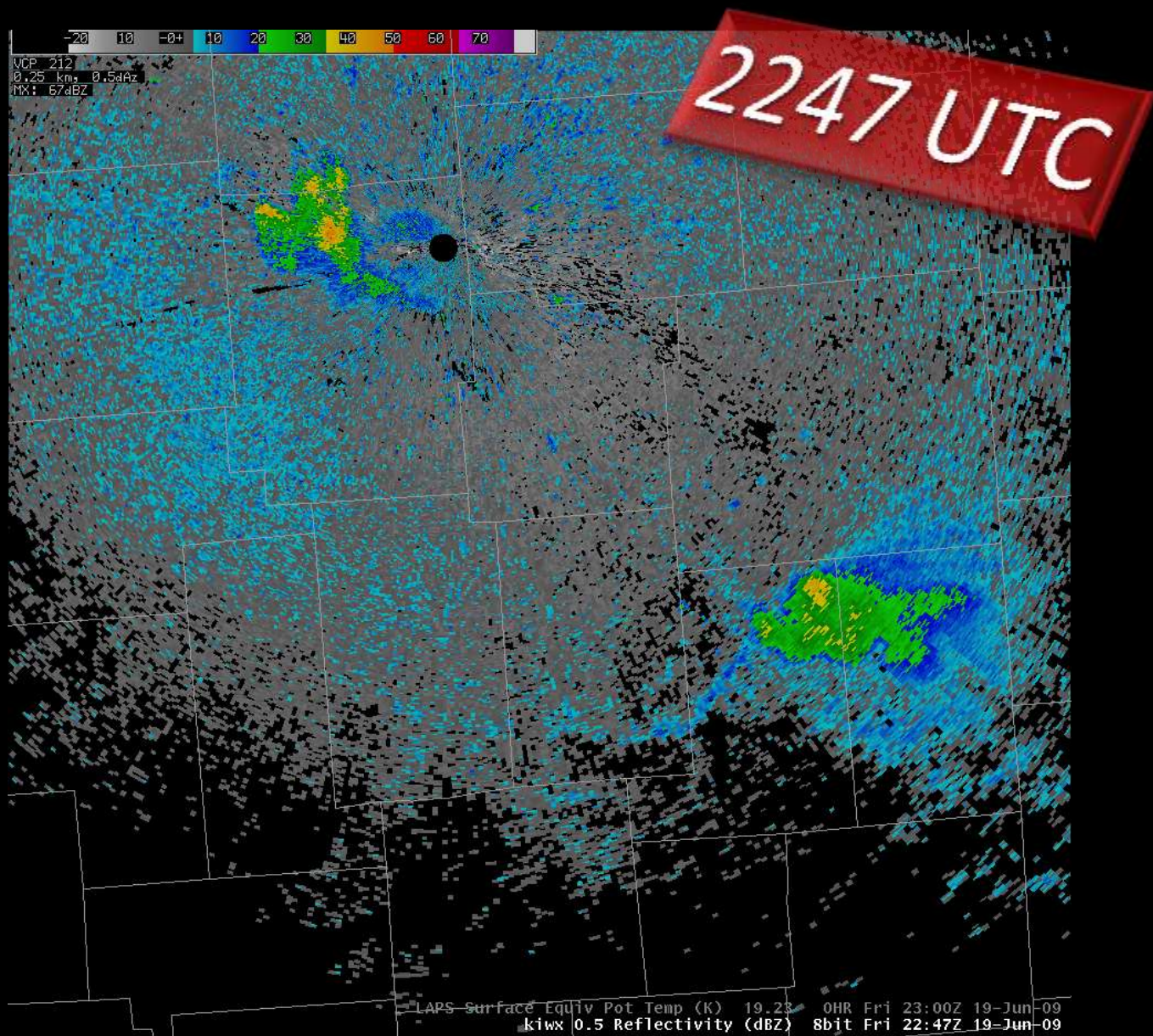
0.5 Degree Reflectivity



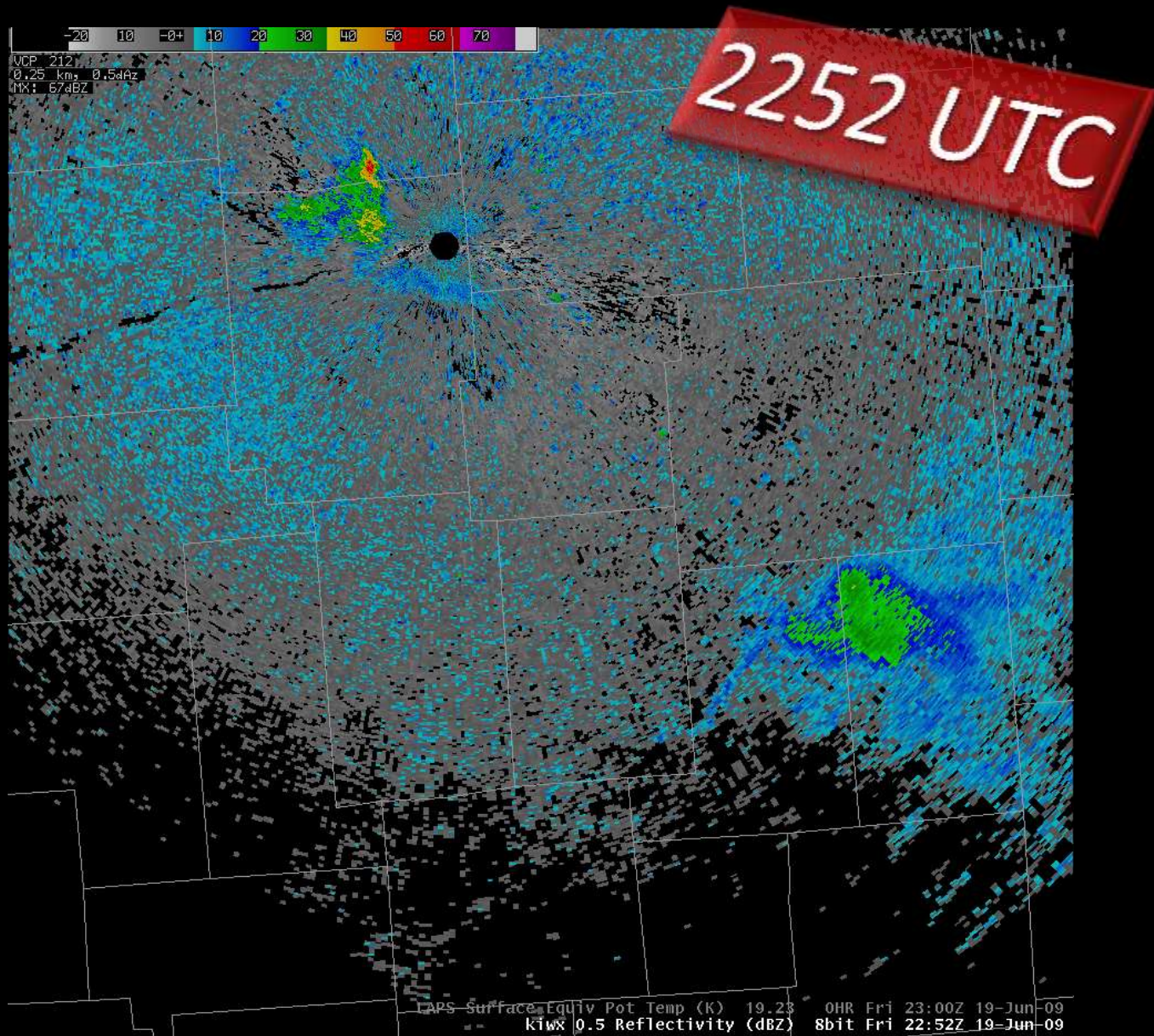
0.5 Degree Reflectivity



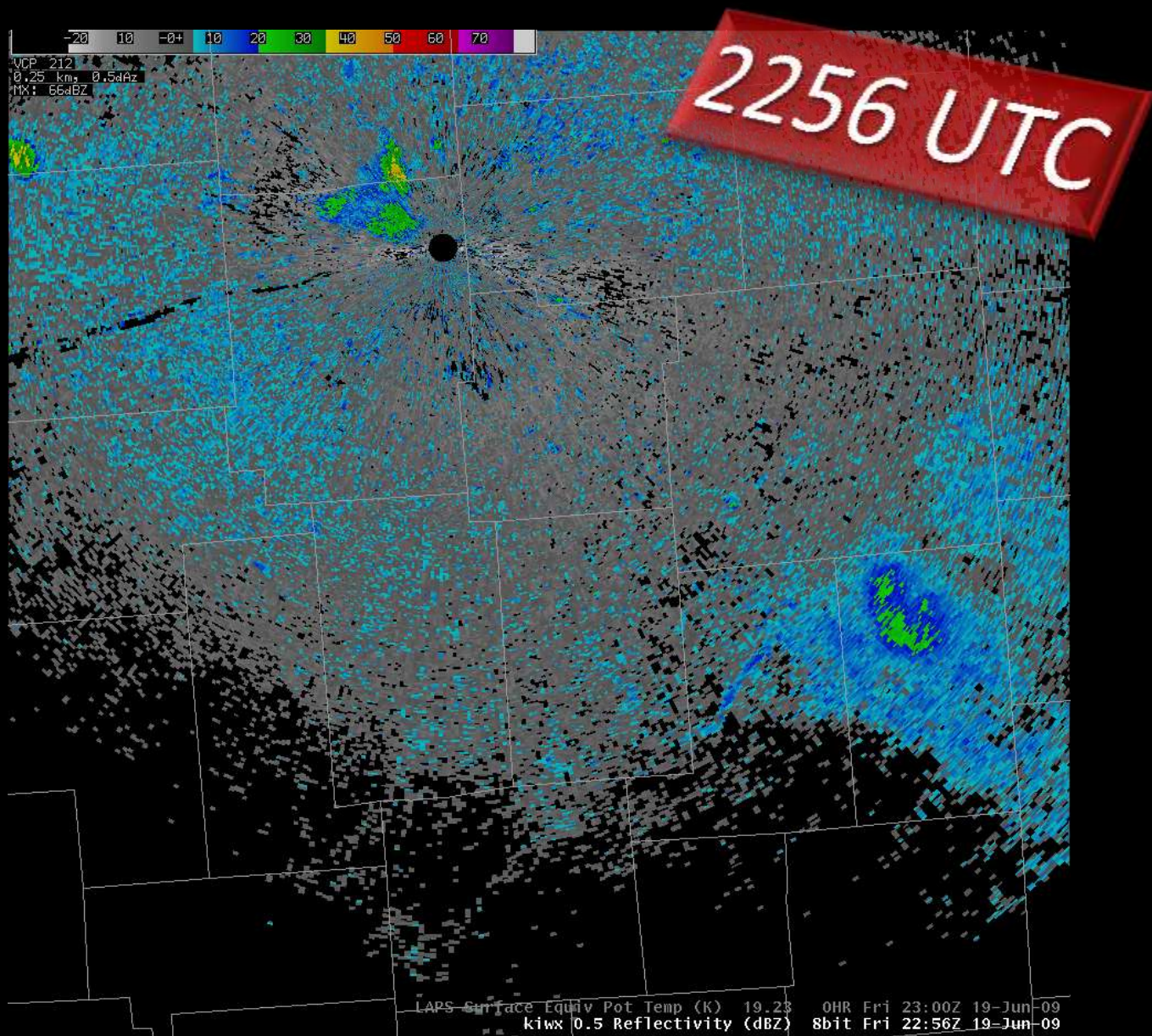
0.5 Degree Reflectivity



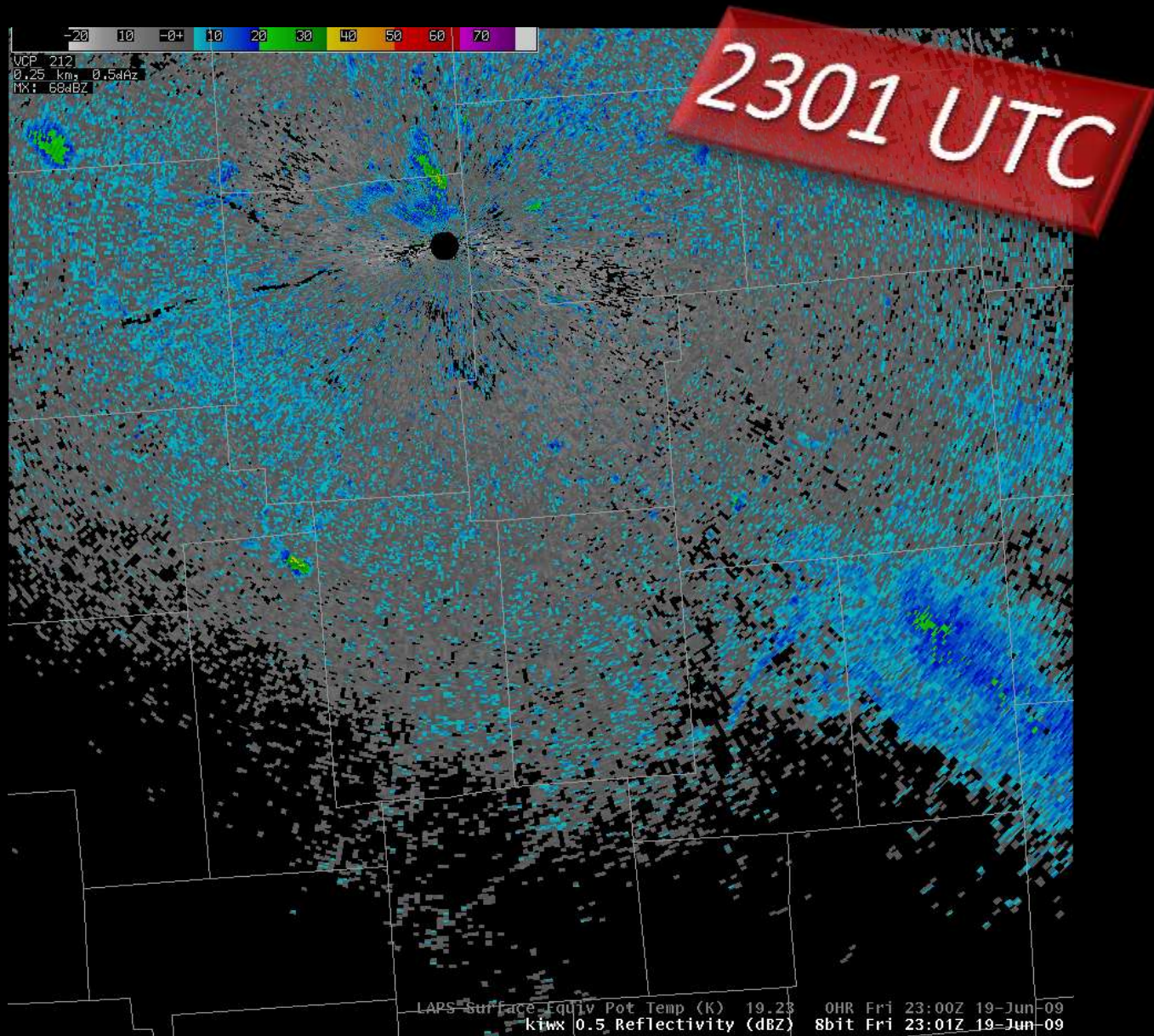
0.5 Degree Reflectivity



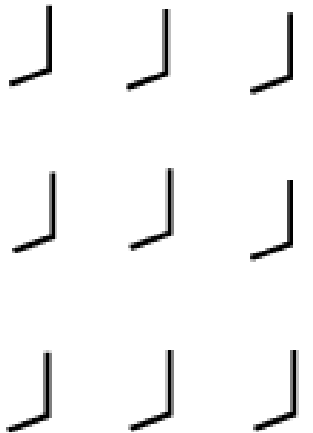
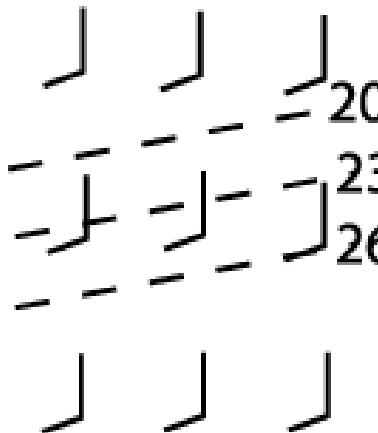
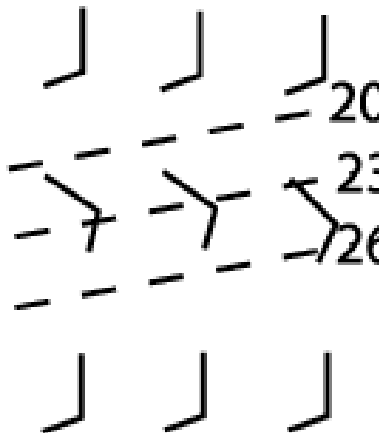

0.5 Degree Reflectivity



0.5 Degree Reflectivity

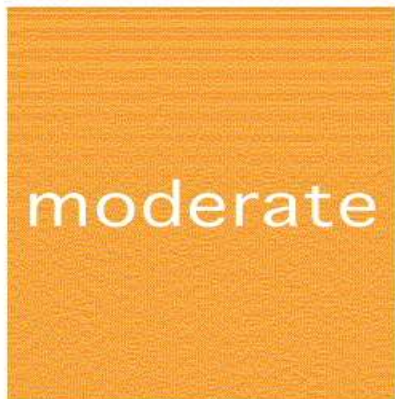


So Why No Tornado?

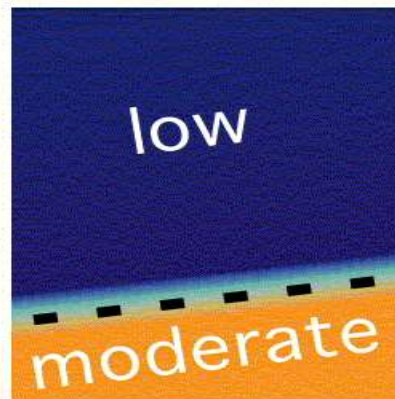
			
<p>Uniform low-level flow</p>	<p>Temperature contrast develops</p>	<p>Horizontal vorticity generation alters the low-level wind fields</p>	<p>Horizontal vorticity persists after temperature contrast weakens</p>

Conceptual Model of Favorable Tornado Boundary

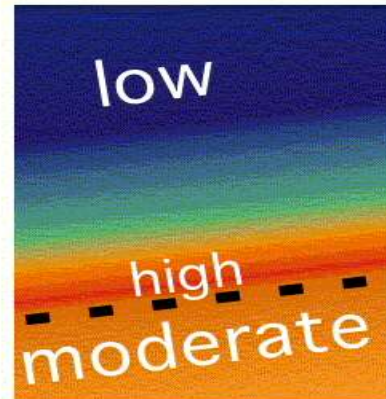
Low  High



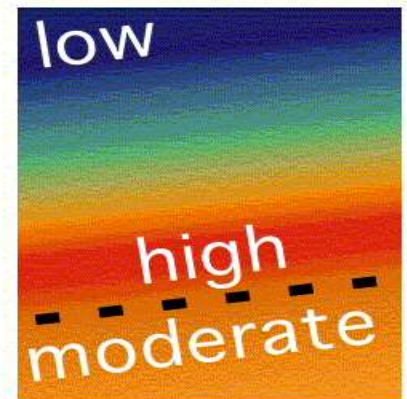
Uniform
low-level
 θ_e



Outflow
boundary
forms



Outflow
boundary
modifies



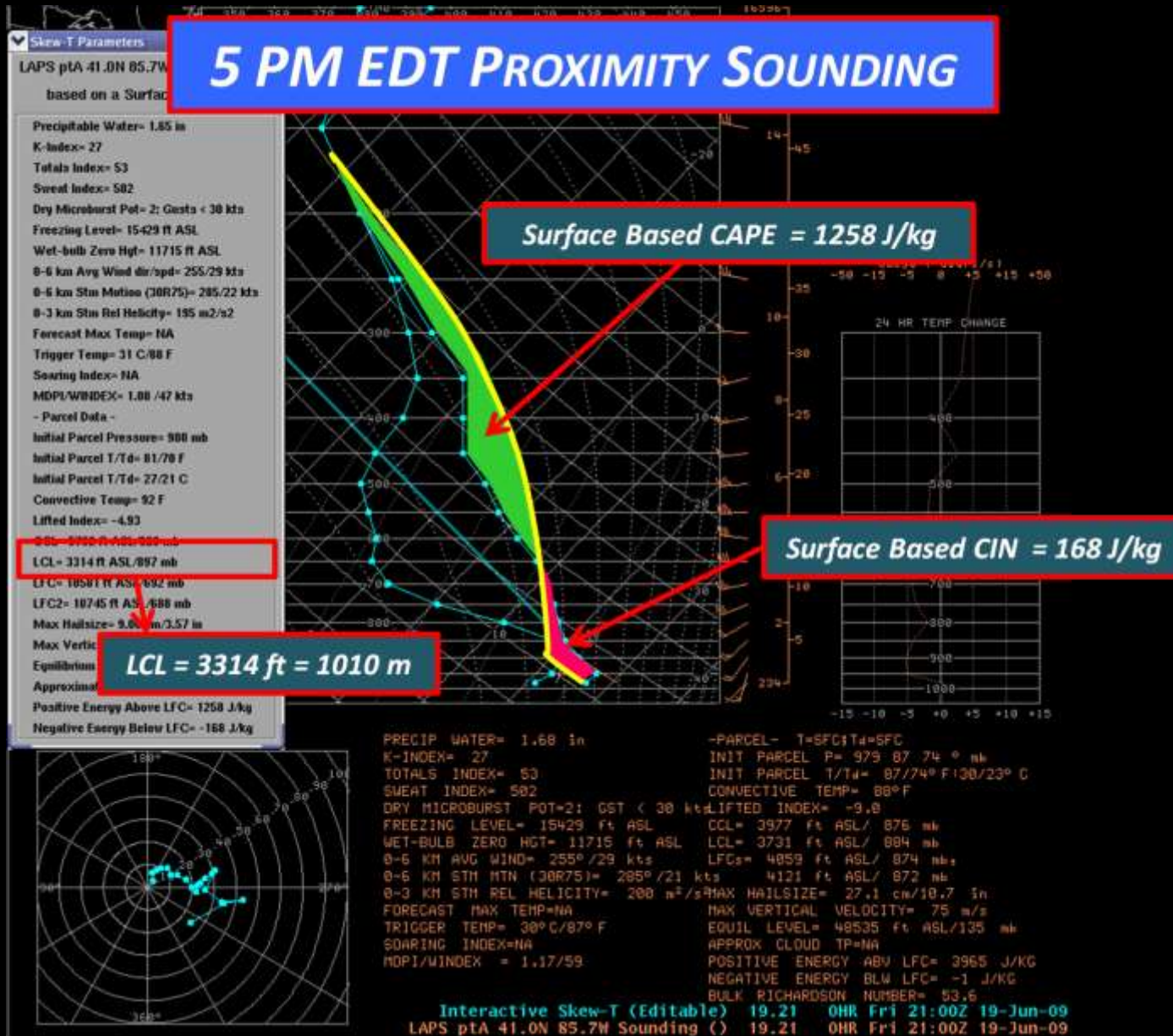
Greatest
modification

One that is rich in high Theta-E
10-30 mi. north of boundary

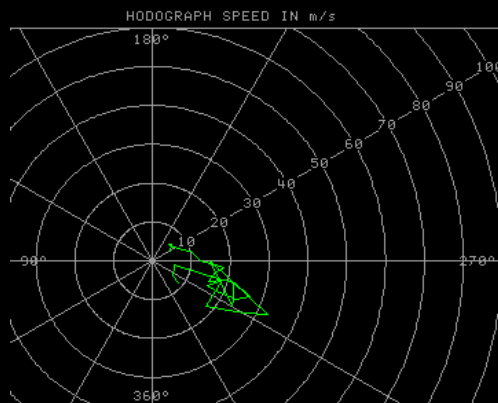
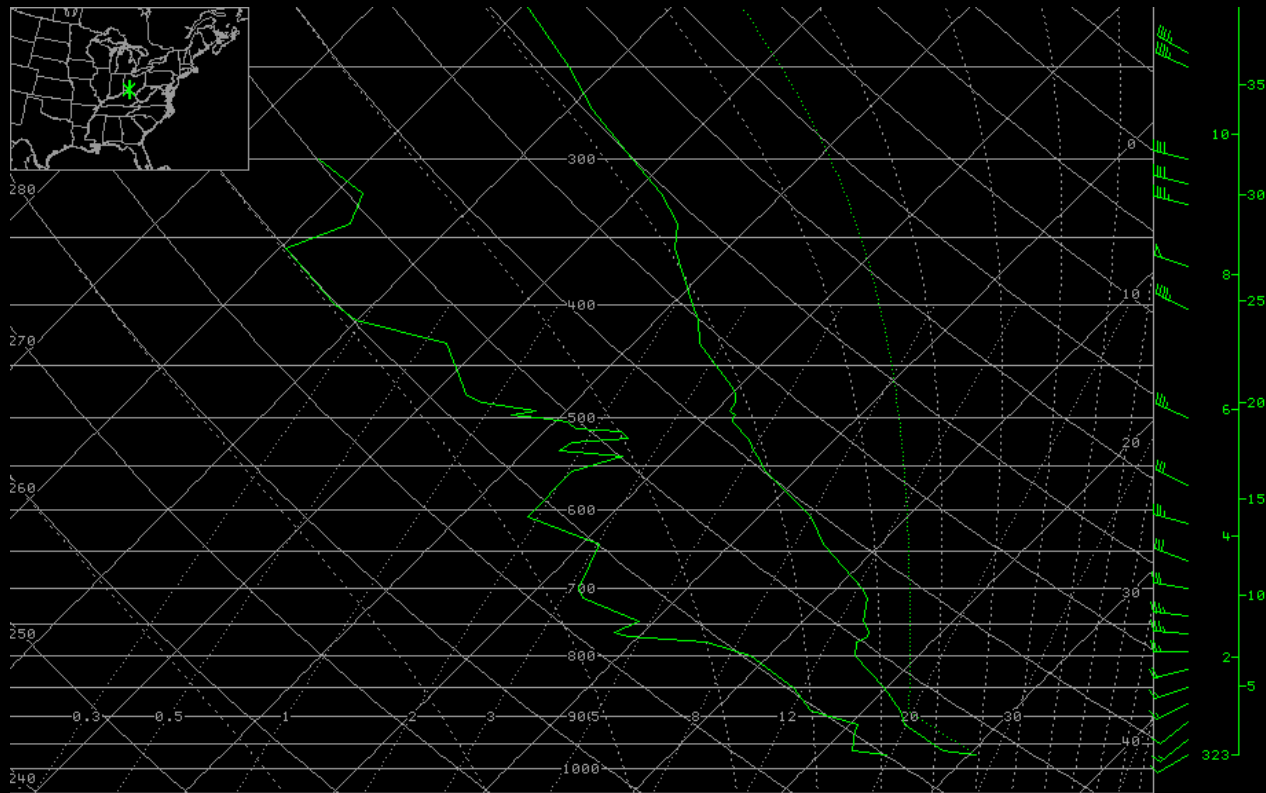
Markowski 2002 from Grant 2008

LAPS Proximity Sounding

(Adjusted to Reflect Surface Conditions North of the Boundary)



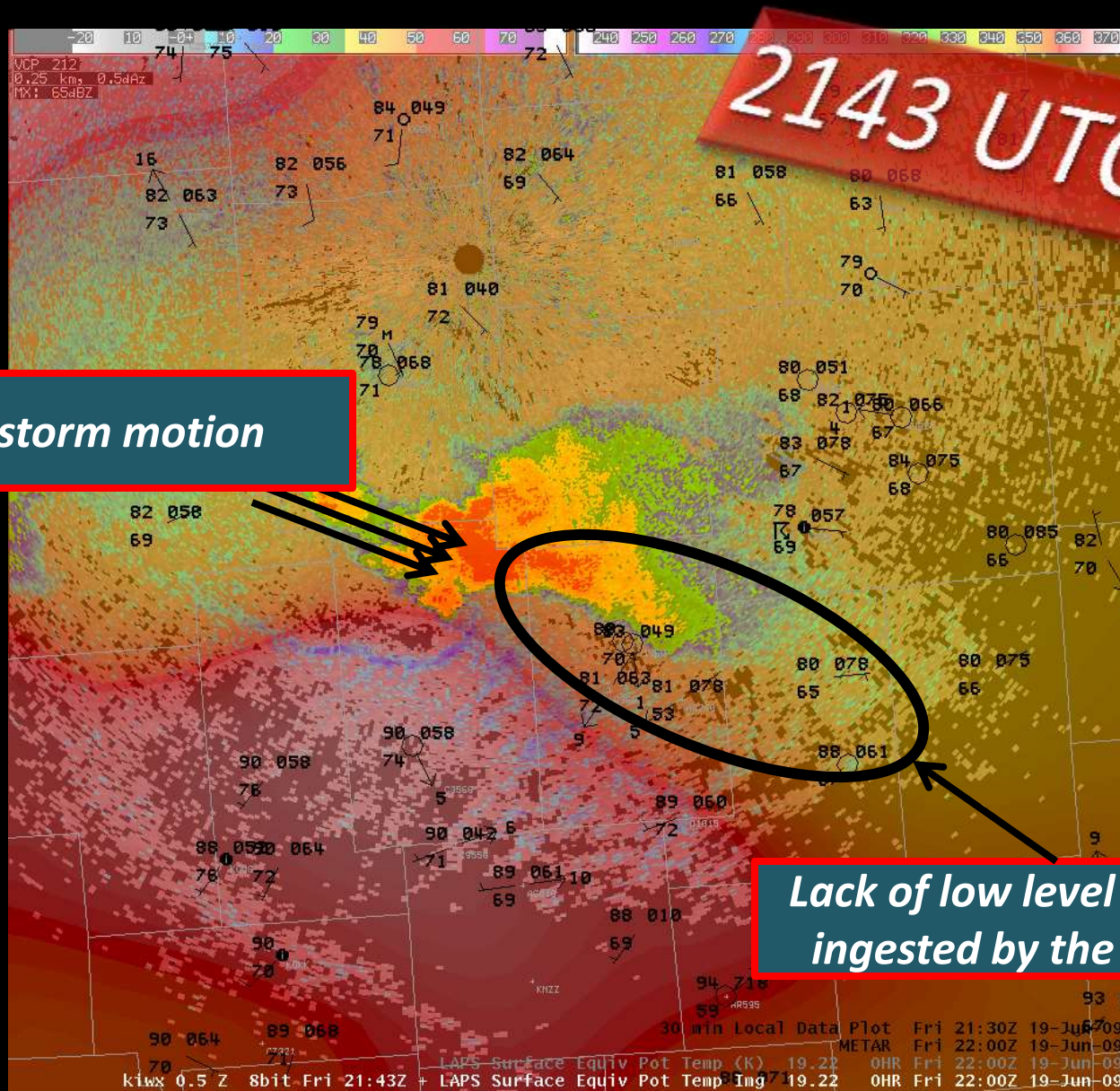
18 KILN UTC Observed Sounding

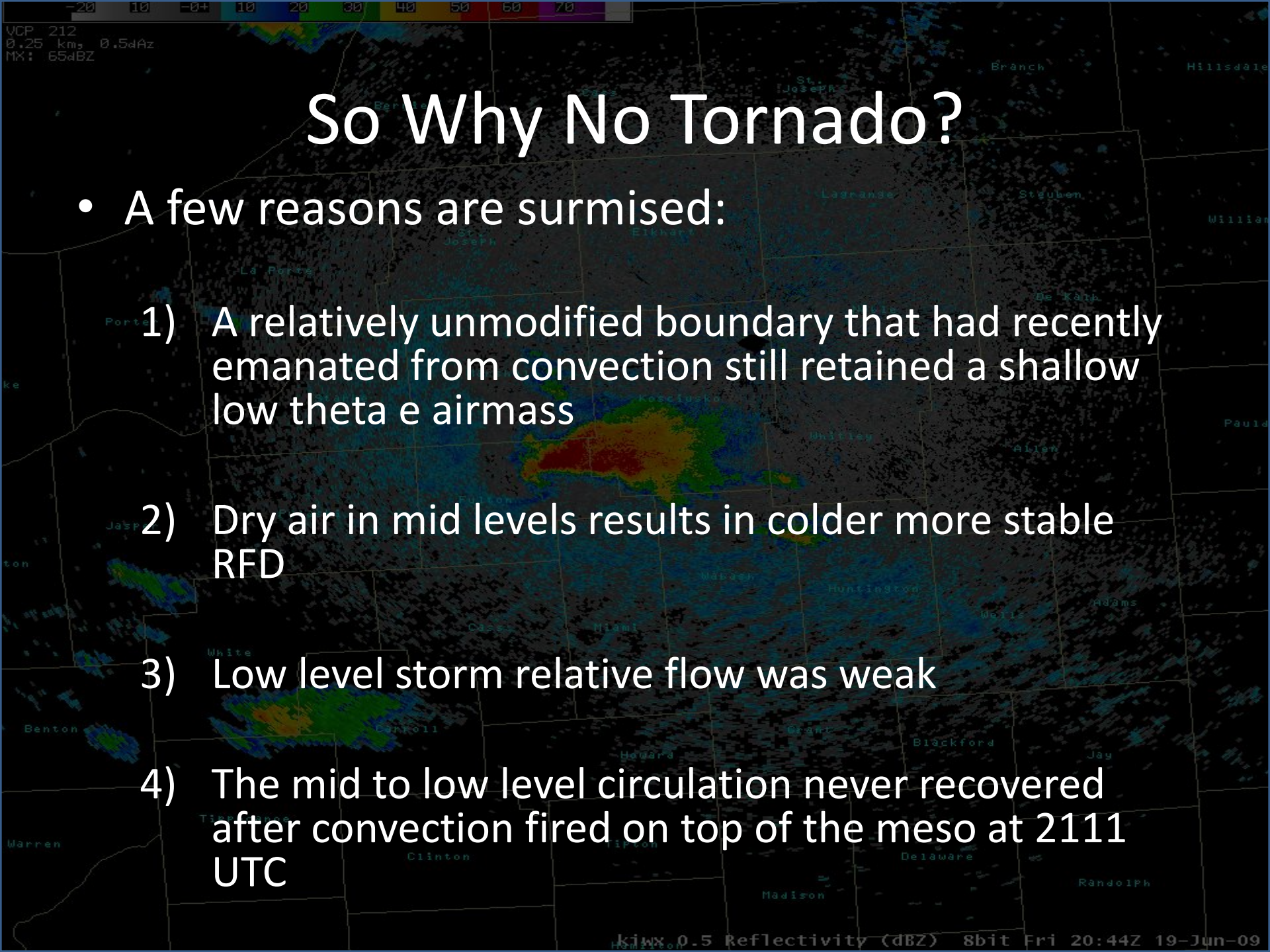


PW= 1.38 in
 K-IDX= 23
 TOT IDX= 50
 SWT IDX= 254
 DMP=2: GST < 30 kts
 FRZ LVL= 15463 ft ASL
 Tw ZERO= 12456 ft ASL
 AVG WND= 278°/25 kts
 STM MTN= 308°/18 kts
 STM HEL= 131 m²/s²
 FCST MAX TEMP=NA
 TRGR TEMP= 30° C/86° F
 SOAR IDX=NA
 MOPI/WINDEX = 1.31/56

-PARCEL- T=SFC;Td=SFC
 PARCEL P= 972 mb
 PRCL T/Td= 86/76° F/30/24° C
 CONV TEMP= 85° F
 LIFT IDX= -11.2
 CCL= 3034 ft ASL/ 908 mb
 LCL= 3567 ft ASL/ 891 mb
 LFC= 3567 ft ASL/ 891 mb
 MX HAILSZ= 36.8 cm/14.5 in
 MX VERT VEL= 88 m/s
 EQUIL LVL= 50073 ft ASL/124 mb
 MX CLD TOP=NA
 POS AREA= 5407 J/KG
 NEG AREA=NONE
 RICH NBR= 109.5

LAPS Surface Theta E & Observations





References

- Brooks, H.E., and J.P. Craven, 2002: A database of proximity soundings for significant severe thunderstorms, 1957-1993. Preprints, 21st Conf. on Severe Local Storms, San Antonio, TX, Amer. Meteor. Soc., 639-642.
- Grant, B.N., 2008: Basics of tornadic storms. PowerPoint presentation, http://wdtb.noaa.gov/courses/dloc/workshop/presentations/tor-fcstg_basics.ppt.
- Klemp, J.B., and R. Rotunno, 1983: A study of the tornadic region within a supercell thunderstorm. J. Atmos. Sci., **40**, 359–377.
- Markowski, P. M., E. N. Rasmussen, J. M. Straka, 1998: The occurrence of tornadoes in supercells interacting with boundaries during VORTEX-95. Wea. Forecasting, 13, 852-859.
- _____, J. M. Straka, E. N. Rasmussen, 2002: Direct surface thermodynamic observations within the rear-flank downdrafts of non-tornadic and tornadic supercells. Mon. Wea. Rev., 130, 1692-1721.

References

- Redmond, C. and Swiger, T., 2009: Storm chase 6-19-09. Website, http://www.scalialab.com/news/chase_6-19-09.html
- Thompson, R. L., and R. Edwards, 2000c: RUC-2 supercell proximity soundings, Part II: An examination of storm-relative winds normalized to supercell depth. Preprints, *20th Conf. Severe Local Storms*, Orlando, Amer. Meteor. Soc.
- Thompson, R. L., C. M. Mead, and R. Edwards, 2007: Effective storm-relative helicity and bulk shear in supercell thunderstorm environments. *Wea. Forecasting*, 22, 102–115.
- Weisman, M. L. and J. B. Klemp, 1982: The dependence of numerically simulated convective storms on vertical wind shear and buoyancy. *Mon. Wea. Rev.*, 110, 504–520.

Special Thank You

- Jeff Logsdon
- Justin Arnott
- Todd Holsten
- Jon Chamberlain
- Lonnie Fisher
- Patrick Murphy
- Sam Lashley